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ABSTRACT

The focus of this dissertation was to develop a model instructional unit to teach story problem-solving skills to fourth- and fifth-grade pupils and to determine the model's effectiveness. Subjects were randomly selected pupils in the Long Beach Unified School District. The model unit consisted of a sequenced continuum of instructional objectives with student activities, instructional procedures, and student practice sheets. The objectives extended from pupils identifying numerical actions in pictures up to and including two-step story problems. Instructional emphasis was placed on understanding problem situations, recognizing mathematical processes, and relating those processes to appropriate computational operations. The pre- and posttest scores of subjects were compared to those of controls receiving standard textbook instruction. Significant differences were found at the .02 level on adjusted post-test scores for fourth-grade students, and at the .01 level for fifth-grade students. The results suggest that the new instructional method, within the conditions of the experiment, shows promise for further research. (MP)

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ABSTRACT

THE EFFECT OF A MODEL DESIGNED TO FACILITATE MATHEMATICAL STORY PROBLEM-SOLVING SKILLS IN CHILDREN IN THE INTERMEDIATE ELEMENTARY GRADES

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A Dissertation Submitted in Partial Fulfillment of
The Requirements for the Degree of
Doctor of Education

WALDEN UNIVERSITY

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ABSTRACT

More effective instructional techniques are needed to teach intermediate elementary school pupils math story problem-solving skills. The latest research findings concerning problem-solving strategies and instructional methods are reviewed. The relationship between reading ability and success in problem solving is reviewed as are methods of measuring problem-solving skills.

The focus of the study was the development of a model instructional unit to teach math story problem-solving skills to intermediate elementary grade children and determination of the model unit's effectiveness on a random sampling of intermediate grade pupils in the Long Beach Unified School District. The model instructional unit consisted of a sequenced continuum of instructional objectives with student activities, instructional procedures, and student practice sheets. The objectives extended from pupils identifying numerical actions in pictures up to and including two-step math story problems. The emphasis of instruction was placed on understanding the problem situation, recognizing the mathematical process involved in the problem,

and relating those processes to appropriate computational operations used in solution procedures. Word or story problems are the means by which children are provided practice in solving problems.

This study compared the pre-posttest scores of pupils exposed to the model instructional unit with those of a control group receiving the standard textbook method of instruction.

An analysis of covariance testing for significance of differences between adjusted posttest scores of twenty-five fourth grade pupils yielded an F-ratio significant at the .02 level. The analysis of covariance testing for significance of differences between adjusted posttest scores of twenty-two fifth grade pupils yielded an F-ratio signficance at the .01 level.

The experimental group of fourth grade pupils exceeded the control group by 3.27 adjusted mean raw score points and the experimental group of fifth grade pupils exceeded the control group by 4.65 adjusted mean raw score points.

This exploratory study suggests that the new math story problem-solving instructional method, within the conditons of the experiment, shows promise for further research.

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CHAPTER I

INTRODUCTION

Teaching elementary school children how to solve mathematical story problems has been and continues to be a difficult task for many elementary school teachers. Basic mathematics textbooks do not often provide classroom teachers with a developmental program that is effective in teaching children the skills involved in solving mathematical story problems.

Solving mathematical story problems is a practical means of learning and practicing beginning problem-solving skills. Solving story problems requires students to analyze typical problem situations, select appropriate mathematical operations for their solutions, and interpret and evaluate those solutions.

It is the intent of this researcher to develop a model instructional unit that provides teachers with a sequential continuum of instructional objectives involved in learning the skills necessary to solve math story

problems. Included with each objective are suggested learning activities, teacher guidelines, and student practice sheets.

This model instructional unit will be designed to bridge the gap between research and practice by incorporating knowledge gained through recent research into a practical day-by-day program that will enable classroom teachers to become more effective in teaching math story problem-solving skills to elementary school children.

The Problem

Current elementary mathematic instructional programs are not very effective in teaching intermediate elementary school children mathematical problem-solving skills. Much concern throughout the country has been expressed about low achievement scores in problem solving. The question, "Why can't children solve story problems?" was the opening question to two articles in the Arithmetic Teacher (West, 1977; Zweng, 1979).

Test data for problem solving of students from the First National Assessment of Educational Progress were discouraging. Results indicated that students and graduates from our nation's schools have serious deficiencies in

their problem-solving abilities (Schaaf, 1979). For example:

> In the results from the Second Assessment of Mathematics, only 56% of the 13-year-olds answered the following multiple-choice problem correctly, although the multiplication required (5 x 2) is extremely simple.
>
> One rabbit eats 2 pounds of food each week. There are 52 weeks in a year. How much food will 5 rabits eat in one week?
>
> Many 17-year-olds had difficult in figuring out the unit price for kilowatt hours consumed when shown a sample electric bill. Approximately 10% set up the problem and divided correctly; another 7% set up the problem correctly, but made an error in division. (Ward, 1979, pp. 42, 43)

The 1977-78 National Assessment of Mathematics provided a comprehensive survey of students' present levels of mathematics achievement. National Assessment convened a panel of persons active in the field to interpret the results and to consider the implications for mathematics education (Ward, 1979). "The panel felt that problem solving is a major area of concern in mathematics education" (p. 42).

One of the major recommendations listed in the summary of findings of the Annual Report of Student Achievement in California Schools for the year 1980-81 was that more instructional emphasis is needed on the high level thinking skills involved in problem solving. It further stated that

drill and practice on basic computational skills should be balanced with the development of skills in problem solving. Teachers and developers of instructional materials should try to use materials that help students at all ability levels to develop skills in problem analysis. Teachers should be provided with instructional materials that will aid them in helping students solve problems (Student Achievement in California Schools, 1981).

Data from several state assessments further indicated that achievement on problem-solving tests is lower than parents would like it to be (Meiring, 1980). In the past, very little emphasis has been put on math problem-solving skills. Computation, with some attention to concepts and application, received the major portion of mathematics' time and attention. The more recent movement, "back to the basics," has further caused a narrowing of the math curriculum. Computational skills, knowledge of facts, and definitions have been stressed with less time given to problem-solving skills.

Few textbook series meet the criteria necessary for an effective program for teaching problem solving to elementary school children. Most textbooks organize problem solving to provide practice with a specific kind of process

or operation. Problems, therefore, become mere practice exercises with little attention given to the processes involved in true problem solving. Very little guidance is given on how to select the appropriate mathematical process for solving a mathematical problem.

Many elementary mathematics textbooks offer an approach to problem solving which requires a student to look only for "key words" or "clues" in story problems to help the student decide which operation to use rather than understanding the meaning of the problem to be solved (Ward, 1979). In an effort to make problem stories easier for poor readers, publishers have presented problems with as few words as possible and the least amount of complexity: "52 marbles. 17 taken away. How many left?" (Ward, 1979, p. 43); "30 flags. 5 in a row. How many rows?" (Nichols, et al., 1981, p. 131); "There are 126 students. 89 students went berry picking. How many students did not go?" (ibid., p. 93).

Teachers are often not well prepared to teach problem solving. Teachers seldom know effective ways to approach problem solving and often rely on memorization and drill as alternatives. Mathematics instruction in problem solving is only a minor part of mathematics instruction in

elementary schools. Wilson, a member of the review panel for the National Assessment shared his finding that, "in his experiences in schools, many teachers in the schools he visited simply did not conduct lessons on problem solving" (cited by Ward, 1979, p. 44).

The Purpose

It is the intent of this researcher to design a model instructional unit that can be implemented to teach elementary school children the beginning problem-solving processes through the use of mathematical story or word problems. A sequenced continuum of instructional objectives with student learning activities, teacher guidelines, and student practice sheets will be developed that classroom teachers can use to teach basic problem-solving skills involved in math story problems.

The effectiveness of the unit will be evaluated on a random sampling of intermediate elementary school students. The achievement of an experimental group will be compared with a similar control group drawn from the same school but taught by a different, yet similarly experienced, teacher.

Significance

Problem solving is a recognized educational goal. The ability to solve problems is one of the most important objectives in and the ultimate aim of all mathematical programs. Problem solving has become a major area of concern in mathematics education and should be given more attention in the elementary schools. It is imperative that more effective instructional materials and techniques be developed. Classroom teachers need a sequenced instructional program for teaching skills involved in mathematical problem solving; the proposed model hopefully meets this goal.

After reviewing the data reported by the National Assessment of Educational Progress (NAEP), the review panel recommended that problem solving should receive more emphasis in the schools; more attention should be devoted to preparing teachers to teach concepts and problem solving; and that further research on methods of teaching problem solving is necessary so teachers can approach it with some confidence that the strategies they are using will be effective (Ward, 1979). Panel member Wilson concluded by stating, "What we math educators have been doing in the problem-solving area does not appear to be working" (cited by Ward, 1979, p. 45); Dilworth concurred by saying that, "New

approaches are needed to improve problem-solving performance" (cited by Ward, 1979, p. 45).

The National Council of Teachers of Mathematics (NCTM) had made recommendations for the directions mathematic programs should be taking in the 1980s. NCTM's recommendations are based on studies funded by the National Science Foundation and from two mathematics assessments of the NAEP. The NCTM specifically recommended that,

> Problem solving must be the focus of school mathematics in the 1980s. The development of problem-solving ability should direct the efforts of mathematics educators in the 1980s. Performance in problem solving will measure the effectiveness of our personal and national possession of mathematical competence. (National Council of Teachers of Mathematics, 1980, p. 16)

Drucker states, "The essential new fact is that a developed society and economy are less than fully effective if anyone is educated less than the limit of his potential" (1973, p. 232). The fact that a society is more effective when each and every person is educated to the limit of his/her potential makes this study extremely significant, relevant and appropriate for our time.

The aim of education is to prepare children for the future. The effective teaching of problem-solving skills to children will result in more adults being able to cope with

the demands of the world in which they will be functioning. It is essential that children and adults be able to apply math problem-solving skills to real life situations, to personal finances, and to the world of work.

An effective instructional model to facilitate math word problem-solving skills in elementary school children may become an inherent part of successful educational processes and will have a positive effect on educational and social change.

Nature of the Study

The study will involve an extensive review of the latest research concerning the teaching of problem-solving skills in the elementary grades. The literature review will concentrate on problem-solving strategies and instructional implications that deal specifically with solving mathematical word problems used in the intermediate elementary school grades. The relationship of reading and problem solving will be discussed and a math vocabulary list will be developed. The researcher will incorporate practical knowledge gained through years of teaching experience with research findings into a practical day-by-day instructional model to teach intermediate elementary children how to solve math story problems.

It is estimated that it will take eight weeks to perform a pilot study to test the effectiveness of the model instructional unit. The effectiveness of the model instructional unit will be determined by administering alternate forms of a pre-norm and post-norm referenced standardized math problem-solving test to a random sampling of intermediate elementary pupils who have been exposed to the teaching methods and procedures as presented in the model unit.

Alternate forms of the same norm-referenced pretest and posttest will be administered to a control group exposed to the conventional textbook methods used in teaching intermediate elementary pupils skills in solving math story problems. The posttest scores of the norm-referenced standardized test scores of the experimental group will be compared with the posttest scores of the control group, both adjusted for unequalities in their respective pretest scores.

Scientific Hypotheses

Fourth grade elementary school pupils exposed to the new model instructional unit will demonstrate an increased ability to solve math story problems when compared with a group of fourth grade elementary pupils exposed to the conventional methods of instruction as measured by alternate

forms of a pre-norm and post-norm referenced standardized test made up of typical story problems used in the fourth and fifth elementary grades (Iowa Tests of Basic Skills--Math Problem Solving, hereinafter referred to as Iowa Test-math).

Fifth grade elementary school pupils exposed to the new model instructional unit will demonstrate increased ability to solve math story problems when compared with a group of fifth grade elementary pupils exposed to the conventional methods of instruction as measured by alternate forms of a pre-norm and post-norm referenced standardized test, Iowa Test-Math.

Null Hypotheses

There will be no significant difference between samples of fourth grade elementary pupils exposed to the new model instructional unit and the fourth grade students exposed to the conventional methods of instruction.

There will be no significant difference between samples of fifth grade elementary pupils exposed to the new model instructional unit and the fifth grade students exposed to the conventional methods of instruction.

Summary

Teaching elementary students how to solve mathematical story problems continues to be a difficult task and is in need of solutions. Current elementary instructional programs are not very effective. Few textbooks series meet the criteria necessary for an effective program for teaching problem solving to elementary school children. Teachers are often not well prepared to teach problem solving and seldom know effective ways to approach instruction of problem-solving skills. Test data indicates that students and graduates from our nation's schools have serious deficiencies in their problem-solving abilities.

Problem solving is recognized as a major educational goal and has become an area of concern in mathematics education. The NCTM is recommending that problem solving be the focus of school mathematics during the 1980s.

Solving mathematical story problems is a practical means of learning and practicing beginning problem-solving skills. It is the intent of this researcher to bridge the gap between research findings and everyday practice by designing a day-by-day model instructional unit that can be implemented by classroom teachers for teaching mathematical story problem-solving skills.

A pilot study to test the effectiveness of the model instrucitonal unit will be conducted by the researcher. It is hypothesized that children who have been exposed to the model instructional unit will show an increased ability to solve mathematical story problems.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Franklin B. Walter, Superintendent for Public Instruction, Ohio State Department of Education, said:

> Problem solving has long been recognized as an educational goal. And as we move closer toward the 21st century, it is rapidly becoming an increasingly important area for competence. To equip students with the appropriate problem-solving skills for future citizenship responsibilities will require careful curriculum planning, systematic instruction, and the commitment and professional expertise of teachers. (cited by Meiring, 1980, p. 2)

There is substantial agreement that the ultimate aim of learning mathematics is to be able to solve problems. That problem solving is the core of all mathematics is widely recognized by educators. However, the role problem solving should play in the elementary school curriculum is unclear. How to develop the abilities associated with it is yet to be determined (Shumway, 1980). Increased awareness of the importance of problem solving and of the difficulty of problem-solving instruction has resulted in increased

efforts to identify specific instructional techniques for teaching problem-solving skills.

Definition of Problem Solving

The Department of Defense Dependents School says:

> Problem solving is the process of applying previously acquired computational skills and concepts to relevant situations by translating them logically into mathematical expressions, calculating the answers, and interpreting the results. (1978, p. 2)

In the Addendum to the California Mathematics Framework, the definition of problem is given as "a situation involving some knowns and unknowns which is not simple to resolve, i.e., a situation that cannot be solved by a familiar rule or algorithm" (California Department of Education, 1980, p. 8). A definition of a problem which is broader in scope is:

> A problem (relative to mathematical problem-solving skills) is a quantified situation which asks for information not explicit in the situation. The required information can only be derived by:
> 1. Understanding the elements in the situation and relationships among those elements;
> 2. Selecting a strategy for representing the elements and relationships symbolically; and
> 3. Manipulation of the symbolic representation according to mathematical agreements so as to reveal the required information. (p. 10)

Problem-Solving Objectives or Purposes

In order to unify instruction in problem solving in mathematics, certain concepts have been identified which may be regarded as instructional objectives for problem solving in mathematics. Stokes (1951) has expressed these concepts in terms of the elementary school learner being able to:

a. Recognize and formulate a problem.
b. Collect needed information and data.
c. Determine the relationships involved.
d. Express the relationship in symbolizations, words, or number symbols involving operations.
e. Find the solution or consequence. (p. 195)

The Addendum to the California Mathematics Framework (California Department of Education, 1980) lists the purposes for teaching problem solving as:

1. To develop an understanding of a broad range of strategies
2. To translate words into mathematical symbols
3. To form mathematical models from real-world situations
4. To develop deductive or convergent thinking skills
5. To improve and enhance decision-making skills
6. To motivate students to learn and appreciate certain mathematical skills
7. To develop mental and logical skills related to creative or divergent thinking. (p. 10)

The Mathematics Framework for California Public Schools (California Department of Education, 1975) states that one major goal of a mathematics program is for pupils

to develop the ability to formulate and solve problems and the ability to apply these problem-solving skills in practical situations. Application of mathematics requires one to (1) formulate problems that are suggested by given situations; (2) construct, if possible, adequate mathematical models of these formulated problems; (3) find the solution of these models; and (4) interpret these solutions back in the original situations. Problem solving requires one to select strategies for the analysis of a given problem and to use certain mathematical skills and techniques identified in the analysis to solve the problem.

The program-level objectives for the problem solving/applications strand are grouped under the following major topics:

1. Problem formulation
2. Problem-analysis strategies and tactics
3. Constructing mathematical models of problems
4. Finding the solution
5. Interpreting the solution

A mathematics program should systematically assist pupils in devising strategies for analyzing problems. The first step is to make sure the problem is understood. The

solvers must understand the problem so well that they can restate it in their own words. The solver should be able to pinpoint the purpose of the problem, to indicate the unknowns, and to identify the given data.

The form of the mathematical model is usually one or more written sentences using mathematical symbols (California Department of Education, 1975). The Ohio State Department of Education's (Meiring, 1980) goal in teaching problem solving is for students to acquire an appreciation for the comprehensive nature of problem solving as well as to develop specific skills. Their ultimate goal is to develop the capability of students to apply school-learned skills successfully to problems arising in real life.

Components or Phases of Problem Solving

The Addendum to the California Mathematics Framework (California Department of Education, 1980) lists four specific components of problem solving that should form the basis of an instructional program in mathematics, K-12: problem formulation, problem analysis, finding the solution, and interpreting the solution.

Problem formulation involves the ability to ask questions or pose problems which clarify the relationships

among the variables in a situation. Problem analysis involves developing strategies and tactics for analyzing problems and devising appropriate mathematical models to represent the problem. (A strategy here means a general plan of attack, while a tactic means a single technique which will help with part of the problem. The first step in developing a strategy is to identify those features which are significant to the central problem. This part may be referred to as analyzing the problem or "planning.") Finding the solution requires computational skills and an understanding of operations and number properties. Interpreting the solution involves reviewing the problem and its solution.

Polya (1957) explains four steps of problem solving. In the first step, the problem solver must understand the question and want to find the answer. The person must recognize what is known, what is unknown, and what conditions are present. In the second step, the problem solver might tentatively try a number of plans before making a decision on one that seems most promising, or the person might think of a related problem that has already been solved. In the third step, the problem solver carries out the chosen plan

to a solution. In the fourth step, the problem solver looks back and checks the solution with the conditions presented in the problem.

D'Augustine (1973) lists six processes that take place in solving problems. They include the following:

1. A problem is recognized.
2. The basic structure of the problem is reduced to a simplified model.
3. Data are gathered or avenues for solution are selected.
4. A value judgment is rendered in selecting the "best" avenue for a solution.
5. The problem is solved and the choice of solution is evaluated.
6. Alternate solutions are tested. (p. 52)

The second process advocated by D'Augustine refers to the models approach which is the technique of having a child read or listen to a story problem and then having him match the situation to some previously learned model. Meanwhile, Suydam (1980) has compiled a list of the steps proposed by Hollowell (1977); Kochen, Badre, and Badre (1976); and LeBlanc (1977):

1. Understanding the problem--an awareness of the problem situation that stimulates the person to generate a statement of the problem in writing, orally, or merely in thought
2. Planning how to solve the problem
   a) Break down the components; enumerate the data; isolate the unknown

b) Recall information from memory; associate salient features with promising solution procedures
c) Formulate hypotheses or a general idea of how to proceed

3. Solving the problem
   a) Transform the problem statement into a mathematical form, or construct representations of the problem situation
   b) Analyze the statement into subproblems for which the solution is more immediate
   c) Find a provisional solution
4. Reviewing the problem and the solution
   a) Check the solution against the problem
   b) Verify whether the solution is correct; if not, reject the hypotheses, the method of solution, or the provisional solution
   c) Ascertain an alternative method of solution

(Suydam, 1980, pp. 38-39)

Problem Solving and Word Problems

According to Earle (1976), "The solution of word problems represents the most common application of knowledge and skills to intellectual or physical problems--real or simulated--in mathematics" (p. 7). Developing problem-solving ability in mathematics requires that elementary students be provided with a wide variety of experiences in problem solving. Well organized programs in mathematics curriculum should begin with genuine, concrete problem situations that the child meets in daily living. However, the major problem situation, real activities, designed to help the child make adjustments in living, ordinarily do not

provide sufficient problem material for a complete program in quantitative thinking. They are not adequate for the development of the comprehensive set of concepts and processes necessary to develop good mathematical problem-solving ability (Stokes, 1951).

Described problem situations in the form of word or story problems must be introduced and presented in the curriculum to provide children with a well balanced mathematical program. Children need to be exposed to contrived problem situations in order to build proficiencies in mathematics itself and to develop specific problem-solving application skills. An instructional program in mathematics should include a substantial number of ready-to-solve problems that are designed to develop and reinforce technical skills and concepts involved in problem solving (Stokes, 1951; California Department of Education, 1980).

A written problem that presents the setting, facts, and problem task is the most common problem-solving format that students experience in structured learning situations (D'Augustine, 1973). Story problems permit application of computational skills and help children learn the skill of translating problem situations into mathematical equations. Learning to translate a problem situation into an open

sentence and then finding one or more numbers that make the sentence true is an important aspect of problem solving (D'Augustine, 1973).

Story problems further require students to recognize, identify, and formulate problems from given situations. They provide practice in analyzing typical problem situations, selecting appropriate strategies in choosing an appropriate mathematical operation for its solution, and interpreting and evaluating those solutions (D'Augustine, 1973; California Department of Education, 1980). Described problem situations, word, or story problems are normally presented in elementary school classrooms by using pictures, short phrases or sentences, paragraphs, or a combination of these forms (Bolster et al., 1980; May, Frye, and Jacobs, 1981; Nichols et al., 1981).

> Story problems bring together four components: (1) imbedding of an arithmetic problem into a social setting; (2) generalizing of the situation to identify common elements that key the child as to how to handle the problem; (3) discriminating to discern how this problem may differ from previous generalized approaches; and (4) understanding of the meaning of the operation required in the solution. (Meiring, 1980)

Earle (1976) states:

> With few variations, experts in both reading and mathematics agree that the following steps represent

a sound general approach to the solution of word problems.

Step 1. Read through the problem quickly. Try to obtain a general grasp of the problem situation and visualize the problem as a whole. Don't be concerned with the actual names, numerals, or values.

Step 2. Examine the problem again. Try to understand exactly what you are asked to find. This may be stated as a question or command. Although it often comes at the end of the problem, it may appear anywhere in the problem.

Step 3. Read the problem again to note what information is given. At this point you are looking for exact numbers and values.

Step 4. Analyze the problem carefully to note the relationship of information given to what you are asked to find (steps 2 and 3). Note information which seems to be missing. Also surplus information.

Step 5. Translate the relationship to mathematical terms. Indicate both the values and operations. This almost always involves planning a sequence of steps which correspond to the operations. The end result will be one or more mathematical sentences or equations.

Step 6. Perform the necessary computation.

Step 7. Examine the solution carefully. Label it to correspond to what the problem asks you to find. Finally, check the value against your grasp of the problem situation to judge whether it seems sensible.(pp. 49-50)

Selection of Problems for Classroom Instruction

Interest

LeBlanc, Proudfit, and Putt (1980) maintain that motivation is a factor that contributes to success in solving story problems and that a climate of relevance and enjoyment is critical for success in problem-solving instruction. However, Cohen (1976) and Travers (1976) report that although studies have investigated what types of problems students prefer, no relationship of these preferences in problem-solving success was found.

Difficulty

LeBlanc, Proudfit, and Putt (1980) have determined that four general factors affect the level of difficulty of story or word problems--the choice of vocabulary, the length and structure of the phrases or sentences, the size and complexity of the numbers and the problem setting, or representation. Suydam (1980), after an extensive review of the research conducted concerning the difficulty level of story problems, concluded that,

> The studies suggested that a problem is more difficult to solve when--
> - it has a lot of words;

- it has more than one step or requires more than one operation for solution;
- the sentence structure is complex;
- it is different in type from the problems preceding it;
- information is not presented in the order in which it will be used;
- it has large numbers. (pp. 40-41)

A publication prepared by the Ohio State Department of Education (Meiring, 1980) stated that problems with too much data and problems with too little data are more difficult than problems limited to essential information. Ward (1979) noted that Dilworth felt that extraneous information in a problem appeared to be very difficult for students to cope with. Later Suydam (1980) agreed with Nelson and his coworkers who determined that many young children seem to experience difficulties in solving problems because of the attention to irrelevant aspects of the problem situation.

The Ohio State Department of Education (Meiring, 1979) reported several findings concerning the difficulty of story problems: Children have more success with problems in which settings are familiar, but problems with unfamiliar settings do not seem to cause undue difficulty; children generally enjoy a variety of problem settings. Children are more successful at solving problems when problem information is presented in the order in which it will be used.

Placement of the question in a problem can affect the amount of time required for its solution, but it does not significantly change the achievement.

Usually, the more complex the algorithm, the more difficult the problem. A problem involving percentage usually presents more difficulty than one involving simple addition. The number of steps is another factor in the difficulty level of the problem. A two-step problem is more difficult than a one-step problem (LeBlanc, Proudfit, and Putt, 1980).

Suydam and Weaver (1975) found agreement among several different researchers:

> Four variables which significantly affected the difficulty of word problems were identified by Loftus (1971): number of operations, sequence of problems, complexity, and conversions.
>
> Burns and Yonally reported that, when the data in each of ten multi-step problems were in the order required to solve them, significantly higher scores resulted than when data were not in the order in which they would be used. For the 95 fifth graders they studied, reasoning ability was positively related to pupil success with problems which presented numerical data in mixed order.
>
> Williams and McCreight (1965) concluded that for fifth and sixth graders, there were "some advantage to the child when the question was placed first," though no significant difference between mean scores was found. Time to solve was less when the question was placed at the beginning.

> Bolduc (1970) also noted no significant difference in first-grade pupils' problem-solving performance when the question was placed first vs. last. (Suydam and Weaver, 1975, p. 118)

Suydam and Weaver found that investigations concerning the affect of familiarity with the settings of word problems on children's success in solving them have been made:

> Brownell and Stretch (1931) reported on the reactions of 256 fifth graders to carefully matched problems at four degrees of familiarity. They concluded that there is "no ground for reasonable belief that problems are made unduly difficult for children by being given unfamiliar settings."
>
> While some other researchers confirmed this finding, there is conflicting evidence on this question. Washburne and Osborne (1926) concluded that unfamiliarity of setting has some influence on success in problem solving, although it is "not as large an element as might be supposed." On the other hand, Sutherland (1942) was among those who found that pupils were decidedly more successful on problems with familiar settings. (1975, pp. 116-117)
>
> Keil (1965) found that pupils who wrote and solved problems of their own were superior in problem solving ability to pupils who had the "usual textbook experiences." (p. 120)
>
> Kamins (1971) attempted to determine if the appearance of familiar settings, things, people, and subjects in the language of word problems would affect the success of black children from a lower socio-economic environment in solving word problems. For the 32 fifth graders involved, no signficant difference in achievement was found between use of problems written by children and textbook problems.
>
> It has been concluded by many researchers that children like a variety of problem settings. It seems important that children be interested in problems and in ways of solving them. (pp. 116-117)

Problem-Solving Strategies

Using a Variety of Strategies

Suydam (1980) has concluded that, "There is no one optimal strategy or heuristic for problem solving" (p. 45). She continues by recommending that children be taught a variety of strategies that can be applied to different problem-solving situations. A general overall plan on how to approach problem solving is, however, helpful.

Previously, Kilpatrick (1978) had suggested:

> Research evidence strongly concurs that problem solving performance is enhanced by teaching students to use a variety of strategies or heuristics, both general and specific. That is, students using a wide range of strategies are able to solve more problems. . . . Different mathematical content evokes different strategies. (p. 191)

In regard to using a variety of strategies in solving problems, Brownell had stated:

> To be most fruitful, practice in problem-solving should not consist of repeated experiences in solving the same problems with the same techniques, but should consist of the solution of different problems by the same techniques and the application of different techniques to the same problems. (1942, p. 439)

Fehr and Phillips (1972) concur by stating:

> There is substantial evidence that children gain more problem-solving skill by solving the same problem in several ways than by solving similar problems in the same way.(p. 435)

Meiring (1980) also agrees:

> A common factor which many researchers cite as making an important contribution to problem solving development is the frequent opportuity to solve good quality problems which can be solved by children in a variety of ways. (p. 13)

Wheatley (1977) had previously agreed:

> Students need to be faced with problems in which the approach is not apparent and encouraged to generate many alternative approaches, testing each hypothesis generated. In this way students will come to understand the nature of problem solving. (p. 38)

Pace (cited by Suydam and Weaver, 1975) notes that giving many opportunities to solve problems and letting children solve problems in a variety of ways were especially helpful. Brownell (cited by Meiring, 1980) suggests that practice in using a method of solution and applying it to different problems results in increased probability that such a practiced method will be available in other problems.

Formal Analysis

Research evidence thus far does not prove that a formal analysis of a word problem (that is, requiring pupils to answer a specific set of questions in order) is an effective procedure for solving word problems (Burch, 1953).

Fehr and Phillips (1972) have concluded from their studies that:

> There is substantial evidence that requiring children to follow certain steps in solving problems leads to poorer overall performance than helping them acquire the requisite general concepts and skills and then letting each child use these concepts and skills in his own best way. (p. 435)

According to Kilpatrick (1978):

> It appears that techniques which attempt to "program" the solver to follow a fixed sequence of steps are not very effective. . . . Experience and some research suggest, however, that certain heuristic procedures which will improve mathematical problem-solving performance can be learned --provided the teacher illustrates how the procedures work; gives ample opportunity for discussion, practice, and reflection; and supports and encourages the learner's efforts. (p. 191)

Talton cites Hanna's 1930 study wherein an experiment was conducted which involved the comparison of three methods for teaching verbal problem solving:

> The methods investigated were: (1) dependencies, diagramming the thought processes involved in verbal problem solving; (2) four steps of problem analysis; and (3) individual, involving no formal method. In conclusion, Hanna stated the problem analysis resulted in the least mean score gain. A significant difference was noted in favor of the dependencies and individual methods, with no difference between the two methods. (1973, pp. 10-11)

Brownell (1942) suggested:

> A problem is not necessarily "solved" because the correct response has been made. A problem is not truly solved unless the learner understands what he/she has done and knows why his/her actions were appropriate. (p. 439)

Problem solving should stress the thinking processes involved in reaching a solution. Overemphasis on answers, computation skills, or procedures will detract from student appreciation of the thinking skills required for solving problems (Meiring, 1980). Research does indicate, however, that some specific and sequenced instruction in problem solving is beneficial in helping students decide which mathematical operation to use in solving word problems:

> Pace (1961) presented one group of fourth graders with systematic instruction in which children not only decided how to solve a problem, but why that process was appropriate, while another group merely solved the problems with no discussion. The first group made statistically significant gains on tests of problem solving. Interviews and others tests used to measure understanding showed that both groups improved, with greater gains for those who received specific instruction. (Suydam and Weaver, 1975, p. 115)

Earle's (1976) observations support other research when he concludes that although there is no one simple way to solve word problems, students must be guided in an appropriate sequence through a variety of problem situations. Guidance is gradually reduced, as student competence increases, until it is withdrawn altogether when the student is able to solve a particular type of problem independently.

> Riedesel (1964) reported that sixth grade classes using specific procedures plus 30 sets of verbal

> problems at two levels of difficulty achieved higher mean gains on problem solving tests than did control groups who followed the regular textbook program. (Suydam and Weaver, 1975, p. 120).

Use of Number Sentences

The Ohio State Board of Education (Meiring, 1980) states:

> The ability to write and solve number sentences for story problems is one of the most useful mathematical skills that children can acquire. [This skill] warrants the time, planning, and careful attention necessary for its development. (p. 44).

Their summary states that having students write open sentences (where they are appropriate) has two advantages: (1) to represent actions or relationships of the problem; and (2) to emphasize operations that must be used to solve the problem. In support of number sentences, "Arnold (1969) reported evidence from sixth graders favoring the expression of problem relationships in number sentences" (Suydam and Weaver, 1975, p. 120).

Wanted-Given Approach

The Ohio State Board of Education (Meiring, 1980) found that:

> One approach to story problems that has met with documented success, particularly with students of lower ability, has been the wanted-given approach

> (Wilson, 1972, p. 79). Such an approach depends upon definition of the four arithmetic operations which permit their use in a wanted-given analysis of a story problem. For example, "addition is an operation used to find the size of the total when we know the size of each part. Subtraction is used to find the size of one part when we know the size of the total and one of its parts." (Meiring, 1980, p. 42)

Use of Key Words or Clues

Some controversy exists concerning the use of clue words for solving word problems. Suydam (1980) reports that the largest proportion of correct responses occurs when key words act as clues for the procedure or operation that can be used for a solution. Children can profit from some instruction directed toward key words, but this instruction should point out the dangers as well as the benefits of relying on key words:

> It should be noted that emphasis upon isolated word cues ("left," "in all," etc.) can be grossly misleading as a problem solving procedure. They may lead pupils away from recognition of the relationships inherent in the problem, which are crucial to its solution. (Suydam and Weaver, 1975, p. 120)

Carpenter and others concluded that:

> Focusing on key words that are genrally associated with a given operation provides a crutch upon which children may come to rely. Such an approach provides no foundation for developing skills for solving unfamiliar problems. (1980, p. 11)

Trial and Error

Trial and error is perhaps the most direct method of problem solving: It simply involves applying allowable operations to the information given. Two methods of trial and error are systematic trial and error and inferential trial and error. Inferential trial and error takes into account relevant knowledge and uses that knowledge to narrow the search (Musser and Shaughnessy, 1980).

Estimating

Zweng (1979) states that although the evidence is not clear, it is obvious that estimating does not help the child select the appropriate operation in solving mathematical word problems. The child must know which operation to use before he or she can estimate.

Guided Discovery Method

Guided discovery is the teaching approach in which the teacher leads pupils to a desired conclusion or behavior with directed questions. The "expository" approach is the method in which the teacher explains or tells the pupils what they are to do to perform a desired behavior. Suydam and Weaver (1973) compared the two approaches:

> When a "guided discovery" and an "expository" approach are compared, "guided discovery" groups have generally been found to achieve higher on tests of (1) retention and (2) transfer. Generally, the "guided discovery groups achieve higher scores for problem solving than do groups taught by "exposition." (p. 2)

Instructional Implications

Success/Positive Attitudes

Brownell (1942) has suggested that, "Instead of being 'protected' from error, the child should many times be exposed to error and be encouraged to detect and to demonstrate what is wrong, and why" (p. 440). On the other hand Suydam (1980) found:

> Positive attitudes toward mathematics were found to be correlated with success in some studies (e.g., Dodson, 1971) and not correlated in others (e.g., Kilpatrick, 1968). Both good and poor problem solvers chose mathematics as the subject least liked, but good problem solvers chose mathematics as their favorite subject more frequently than poor problem solvers did (Robinson, 1973). . . . Lack of concern about messiness or neatness has also been related to success on problem solving. (pp. 37-38)

Selected Techniques for Teaching

There are many specific techniques for teaching children how to solve story or word problems. Just how helpful these techniques are is difficult to determine.

Among some of the techniques which researchers suggest are:

(1) Provide a differentiated program, with problems at appropriate levels of difficulty.
(2) Have pupils write the number question or mathematical sentence for a problem.
(3) Have pupils make drawings and diagrams using them to solve problems or to verify solutions to problems.
(4) Have pupils dramatize problem situations and their solutions.
(5) Have pupils formulate problems for given conditions.
(6) Present problems orally.
(7) Use problems without numbers.
(8) Have pupils designate the process to be used.
(9) Have pupils note the absence of essential data, or the presence of unnecessary data.
(10) Have pupils test the reasonableness of their answers..
(11) Use a tape recorder to aid poor readers.
(Suydam and Weaver, 1975, pp. 119-120)

Some evidence exists to support each of these techniques. Suydam and Weaver (1975) also suggest that:

> Opportunities should be provided for children to determine the question to be answered, select specific facts necessary to solution, and choose the appropriate process for the solution. (p. 115)

Small Group Instruction

Evidence by investigators in verbal problem solving has indicated that children can learn more by working with partners or small groups than by working alone. This evidence, however, is not completely clear.

> Hudgins (1960) reported that fifth graders who worked on sets of verbal problems in groups of four solved significantly more problems than those who worked alone. When they then worked individually, no significant differences were found among their scores. In an extension of this study, Hudgins and Smith (1966) found that for pupils in groups of three, group solutions to problems were no better than the independent solutions of the most able member of the group, if he is perceived to be most able. (If he is not so perceived, the group will do better than he--or change their perception of him.)
>
> Klugman (1944) found that two children working together at grades 4, 5, and 6 solved more problems correctly, but took a longer time than pupils working separately. (Suydam and Weaver, 1975, p. 120)

Children seem to benefit from the discussion required to achieve solutions. According to Meiring (1980), "Some of the most effective problem solving learning can be accomplished through small group situations in which the teacher may or may not be involved" (p. 34).

Allowance of Adequate Time

Suydam (1980) believes children must have sufficient time to solve problems:

> Not all problems can be solved within the confines of one mathematics lesson; some need to be "mulled over" for longer periods of time. Of course, some problems can be solved relatively quickly, but [one should] encourage the expectation that the path to solution will not always be obvious. (p. 38)

Problem solving has two different facets: One is understanding the problem thoroughly and selecting and applying mathematical notions that might lead to a solution; the other is getting the right answer. Getting the right answer should always result from a careful analysis of the problem. Answers are important and the best way to get correct answers is to allow children adequate time to analyze the problem carefully before plunging in (Davis and McKillip, 1980).

An interesting study involving classroom interactions and teacher questioning disclosed that the average wait time (time passing between the teacher's question and a student response before the question is repeated) is about one second (Rowe, cited by Meiring, 1980). A significant aspect of the Rowe study involved the change in character of a class when the teacher consciously increased the wait time. Some of the effects were: the length of student response increased; the number of unsolicited but appropriate responses increased; failures to respond decreased; confidence increased; the number of questions asked by children increased; and the number of experiments they proposed increased (Meiring, 1980).

Use of Manipulatives

After extensive review of research conducted concerning the affect of manipulative materials used during problem solving, Suydam (1980) concludes that,

> Manipulative materials, pictures, diagrams, and similar aids enhance the probability of a problem's being understood and solved correctly. . . . Rarely do studies indicate that there is no relationship between the use of materials and problem-solving success. The evidence supporting the use of concrete and pictorial aids agrees with that found across mathematics education studies, K-8. (p. 42)

Visuality

Moses (1980) reported that problem-solving performance appears to correlate significantly with both spatial skills and the degree of visuality. She found that individuals who were successful at problem solving tended to use visual solution processes.

In a study with fourth grade students, Swart (cited by Suydam and Weaver, 1971) found that pupils who were directed to draw a picture telling the story did as well as those who were taught to write equations to solve the problems. For problems in area measures, those who drew pictures scored significantly higher.

For second graders, Fennema (cited by Suydam and

Weaver, 1971) found no significant difference in overall learning of a principle when learning was facilitated by either a meaningful concrete or meaningful symbolic model, but use of the symbolic model resulted in significantly better transfer.

In a clinical investigation conducted with kindergarten children by Lindvall and Ibarra (1980), correlational evidence supported the assumption that ability to develop a physical model for a story problem is a prerequisite to being able to write a number sentence for it. They concluded that,

> Successful problem solvers abstract the general and essential elements of a story and then proceed to organize and manipulate these elements, either physically or mentally. . . . The idea that pupils who can write a number sentence for a story are also able to develop a general conceptual model and to solve the story using such a model. That is, the students appear to be able to write the number sentence for a story only when they are already able to solve it by using a general conceputal model. The number sentence, then, is only a way of modeling a solution process that has already been completed. (Higgins, 1980, pp. 29-30)

"Bolduc (1970) reported that, for first graders to whom addition problems were read, those presented without a visual aid were significantly more difficult than those with a visual aid" (Suydam and Weaver, 1975, p. 115).

Characteristics of Good and Poor Problem Solvers

Considerable research has been done to determine what skills and traits good problem solvers possess that poor problem solvers do not. Computational skills and intelligence appear to be most important to success but a few general characteristics must be considered.

Computational Skills

Computational skills are commonly considered as correlates of problem-solving success (Dodson, 1972; Jerman, 1974)). Researchers have found that problem-solving ability and computational skill seem to vary with age. It has been reported that computational ability is closely related to problem-solving ability for young children, but there is only a remote relationship for college-age students (Shumway, 1980).

Balow's (cited by Talton, 1973) investigation supports Dodson and Jerman. His findings with sixth grade students revealed that when intelligence was controlled, there was a significant difference associated with computational ability as the subjects in the higher levels of computation produced higher scores in problem solving.

Balow, therefore, concluded that computation ability does have a significant effect upon problem solving ability. Insufficient computation skills is frequently cited by researchers as a reason for children making mistakes in solving problems (Meiring, 1980).

Intelligence

In an investigation of selected mental, mathematical, reading, and personality assessments as predictors of high achievers in sixth grade mathematical verbal problem solving, Talton (1973) concluded that total intelligence is the main individual contributor to high achievement in verbal problem-solving ability.

General Characteristics

Meiring (1980) found:

> Some researchers have identified common traits that good problem solvers possess, hypothesizing that problem solving capabilities in others might be improved by attempting to improve these traits. Among the factors which characterize good problem solvers, the following are the most frequently cited:
>
> - good estimation and analysis skills
> - ability to perceive likenesses and differences
> - reflective and creative thinking
> - ability to visualize relationships
> - strong understanding of concepts and terms
> - ability to disregard irrelvant data

- capability to switch methods easily, but not impulsively
- ability to generalize on the basis of few examples
- ability to interpret quantitative data
- strong self-esteem
- low test anxiety

Reasons frequently cited by researchers for children making mistakes in solving problem include: insufficient computation skills, lack of understanding of concepts, reasoning errors, weak vocabulary and failure to note details. (pp. 12-13)

Dodson's (1972) results indicated that good problem solvers differed from poor ones in several ways. Shumway amplified Dodson's view to say that:

> Among the most prominent differences were that good problem solvers are superior with respect to (a) overall mathematics achievement, (b) verbal and general reasoning ability, (c) spatial ability, (d) positive attitudes, (e) resistance to distraction, (f) level of field independence, and (g) divergent thinking. (1980, p. 297)

Krutetskii's (1976) studies revealed that good problem solvers typically had certain abilities that poorer problem solvers lacked. Shumway amplifed Krutetskii's view to say that:

> (a) the ability to distinguish relevant from irrelevant information, (b) the ability to see quickly and accurately the mathematical structure of a problem, (c) the ability to generalize across a wide range of similar problems, and (d) the ability to remember a problem's formal structure for a long time [are the most typical abilities of good problem solvers.] (1980, p. 298)

Problem Solving and Reading

The relationship between reading ability and success in problem solving is not fully understood. Studies at the upper elementary level indicate that reading is not as big a deterrent as commonly believed. Some studies report a positive relationship between reading ability and success in problem solving, but it may not be of sufficient magnitude to be an accurate predictor of problem-solving success. One study indicated that poor reading was not a factor in half of the incorrectly solved standardized test problems. Reading difficulties appeared to have accounted for no more than 10 percent of the errors. Children who could read the problems simply could not solve them (Suydam, 1980).

According to Zwing (1979):

> The 1972 NAEP Mathematics Assessment results seem to indicate rather clearly that deciding which operation to perform (addition, subtraction, and so on) is the major stumbling block to successful problem solving. Neither lack of computational skill nor according to the Knifong-Holtan study, lack of reading comprehension is a significant factor in the lack of success experienced by many youngsters in problem solving. (p. 2)

There is evidence, however, that special instruction in reading mathematics problems can have a positive effect on success in problem solving (Krulik and Reys, 1980).

Tracy (1944) and Alexander (1960) infer that reading and other interpretive skills should be specifically developed in the problem-solving program. Fehr and Phillips (1972) concur by stating:

> Even children who are good readers of the kinds of stories which appear in their reading books need instruction and practice in reading content materials of the kind found in math textbooks. (p. 426)

In an investigation conducted by Balow (cited by Talton, 1973) in 1964, an accumulation of evidence was gathered to indicate that the reading of verbal problems requires some specific reading skills as well as an acquaintance with the vocabulary employed in verbal problem statements. Suydam and Weaver (1975) found that as early as 1964:

> Vander Linde . . . reported that specific instruction on quantitative vocabulary was effective in increasing problem solving scores for problems in which that vocabulary was used. (p. 115)

Earp (cited by Barnett, Sowder, and Vos, 1980) has suggested that differences in English prose and mathematical word problems require several reading adjustments for mathematical material: (1) a slower reading rate; (2) varied eye movements, including some regressions; and (3) an attitude of aggressiveness and thoroughness. Some of the differences

noted by Earp and Henney (cited by Barnett, Sowder, and Vos, 1980) between reading prose and reading mathematical word problems are the following:

1. Density--mathematical word problems are more compact and conceptually dense than ordinary prose. A paragraph of prose usually contains one major idea, but mathematical word problems often contain several important ideas in a single sentence.

2. Thought units--word problems usually contain relatively short thought units that are closely related to each other. A single problem statement often contains many thought units.

3. Context clues--word problems often lack rich context clues typically found in English prose. Adjectives are usually more important in word problems. They help distinguish between variables or indicate relative magnitudes that must be taken into consideration in solving the problem.

4. Vocabulary differences--often the meaning of a word in a mathematical problem is entirely different from the meaning of that same word in ordinary prose.

5. New terms--some words commonly used in

mathematics have no relationship to the learner's everyday vocabulary.

6. Continuity--prose usually possesses a continuity of subject and ideas from sentence to sentence and paragraph to paragraph. There is often little continuity among word problems in any given set.

7. Reading patterns--normal reading patterns are often ineffective for word problems. Symbols and numerals in word problems can cause breaks in the student's chain of thought. Familiar reading patterns are particularly disturbed when a picture, graph, or chart accompanies the problem statement, requiring the learner to relate portions of the problem statement to the accompanying visual before completing the reading of the problem.

8. Coping with confusion over vocabulary--the student must be able to interpret words in a mathematical context in order to understand the problem clearly (Barnett, Sowder, and Vos, 1980).

The Ohio State Department of Education (Meiring, 1980) summarized that studies show a positive correlation between higher levels of problem-solving abilities and reading, as well as computational abilities. However, part of

this influence may be the result of the correlation of these abilities with IQ. Studies do suggest that activities emphasizing reading skills such as drawing inferences, following directions, sequencing ideas, and identification of main ideas may improve problem-solving abilities.

Measurement of Problem-Solving Skills

Mathematical problem solving involves thought processes that are complex. This complex process of problem solving is difficult to evaluate.

Traditionally, developers of standardized tests and teachers measure students' abilities in problem solving as they do simpler, learner outcomes. The student is presented with a number of word problems and asked to solve them. Then the number or percentage of correct answers is used as an index of the student's problem-solving ability. The scores are sometimes refined by giving partial credit for correct procedures. Generally only the correct answers form the basis for measuring problem-solving ability or achievement. This procedure indicates a limited view of the complex set of skills that underlie problem solving (Krulik and Reys, 1980).

Research in the measurement of problem-solving

skills indicates that problem-solving behavior is variable from situation to situation and from time to time. An individual's response to a given problem is highly subjective. A student's previous background and set of experiences will influence how a problem is perceived and what operating assumptions are made (Meiring, 1980).

> Because problem solving has so many different facets, every effort should be made to utilize a variety of means to evaluate problem solving performance. No single means is adequate in giving a reliable assessment of problem solving skill possessed by a student. (Meiring, 1980, p. 30)

Summary of Literature Review

Increased awareness of the importance of problem-solving skills has resulted in increased efforts to identify improved techniques for teaching problem-solving skills to elementary school children. In order to unify instruction in problem-solving skills in mathematics, instructional objectives for their development have been identified.

Experts in the field of mathematics have formulated specific components of problem solving to form a basis for their instruction. Problem situations in the form of word problems provide children with a means of developing problem-solving skills and of applying mathematical concepts and computational skills involved in problem solving.

Difficulty and interest of word problems are important factors to consider in the selection of word problems for use in the classroom. Several factors have been discovered that affect the difficulty of word problems.

Using a variety of problem-solving strategies is a recommended approach for teaching math problem-solving skills. Research indicates that specific and sequenced instruction is beneficial in helping children decide how to solve a problem. Evidence exists to support the use of several different techniques in teaching children how to solve math story problems.

Good problem solvers possess some skills and traits that poor problem solvers do not. The complex process of problem solving is difficult to evaluate in the classroom setting. The relationship between reading ability and success in problem solving is not fully understood. However, it is generally agreed among researchers that instruction in some specific reading skills is effective in increasing problem-solving ability.

Although a great deal of information has been obtained about factors which influence students' learning of problem-solving skills, and methods of instruction are known that improve problem-solving skills, research on

teaching problem solving remains incomplete. Practical solutions to many of the instructional problems of teaching problem-solving skills remain unresolved.

Within mathematics education, research must continue trying to ascertain the best methods of teaching math problem-solving skills. At the present time, no one method has been demonstrated to be totally effective in teaching math word problems to upper elementary level pupils. Hence, any research that can contribute toward reducing this state of affairs would be beneficial. It is hoped, therefore, that this study will contribute practical solutions to the instructional problems of teaching mathematical problem-solving skills to elementary school children.

CHAPTER III

EXPERIMENTAL DESIGN

Definition of Terms

The following terms are used throughout this research.

Instructional model: A teaching unit which includes day-by-day instructional objectives and procedures for their achievement with follow up practice materials for pupils. The model instructional unit is designed to be used as a standard of excellence to be imitated. Two examples each of Teaching Objectives and Student Practice Sheets are contained in Appendix C, A Description of the Model Unit.

Norm referenced test: An evaluation which compares the student with peers through percentile, grade equivalent scores, standard scores, and so forth.

Sequential continuum of skills: A continuous series of mathematical skills progressing from the least to the most difficult to acquire.

Heuristic--problem-solving techniques that utilize self-educating techniques to improve performance.

Intermediate grades--grades four through six in the elementary school.

Strategy--a general plan or action used to solve a problem.

Standardized test--a test selected in reference to objectives for which norms of performance have been made available and of which the reliability and validity have been determined.

Assumptions

The following has been assumed for this research:

1. The reading performances of the experimental group and the control group are equal at the start of the research.

2. The general intelligence levels of the experimental group and the control group are equal at the start of the research.

3. The teachers of the experimental group and the control group will be equally proficient.

4. The norm-referenced standardized test (Iowa Basic-Math) is valid and reliable and hence realistic for this study.

5. The potency of the experimental variable will be effective after twelve to sixteen hours of instruction.

6. The dependent variable test will be properly administered and scored.

7. The Hawthorne effect was presumed to be equalized for both groups by similar distribution of the experimental arrangements for both treatment groups.

8. The combined subsets of both male and female pupils were not significantly different.

Scope and Limitations

The focus of this study will be the development of a model instructional unit to teach math story problem skills to intermediate grade children and the testing of the effectiveness of this model instructional unit on a random sampling of intermediate grade pupils in the Long Beach Unified School District.

Concerning the external validity limitations, the sampling of pupils will have tested below the 40th percentile on the California Achievement Test in Mathematics, will be within the normal intelligence range, and will have no diagnosed learning disabilities. Results will be limited to defined population and to the two methods investigated.

The instructional objectives of the model unit will be based on those definitions and procedures of problem

solving deemed by researchers as being most appropriate and essential to be achieved by children in the process of learning problem-solving skills.

Word or story problems will be the means by which children will be provided practice in solving problems. The problem situations presented will involve sequential activities that have been determined by research and selected by this researcher as being effective for teaching children problem-solving skills.

The control group will be taught by an experienced teacher under the same conditions the experimental group will be taught. The control teacher will use the basic math textbook currently being used at Signal Hill Elementary School as her guide. The experimental group will be taught by the researcher using the model instructional unit as her guide.

Two alternate forms of a norm referenced standardized text (Iowa Basic-Math) for the pretesting and posttesting will be administered to assure the effectiveness of the unit is evaluated with a standardized, valid, and reliable testing instrument.

The sizes of the samples will be relatively small. The analysis of the results will use a combined boy-girl

sample due to the small anticipated numbers. A high attrition rate may change the composition of the samples. Other formal and incidental learning may influence the results; randomness is expected to control for this.

Procedure

Subjects

The population for the study will include intermediate children enrolled in Signal Hill Elementary School (an ESEA Title I School) in the Long Beach Unified School District who have tested below the 40th percentile on the California Achievement Test in Mathematics. The pupils in both the experimental and control group come from the Signal Hill neighborhood, fall below the 40th percentile in the CAT-Math, are in the normal intelligence range, and have no diagnosed learning disabilities. Pupils will receive the same amount of instruction time under the same teaching conditions.

Sample Study

From this population, an experimental group and a control group will be randomly selected from the fourth grade classroom (R-8) and the fourth/fifth combination grade classroom (R-10) and the fifth grade classroom (R-7) at the Signal Hill Elementary School. The control group will

consist of eight boys and six girls in the fourth grade and seven boys and five girls in the fifth grade with a total of twenty-six pupils. The experimental group will consist of eight boys and seven girls in the fourth grade and six boys and six girls in the fifth grade, with a total of twenty-seven pupils. A total of fifty-three pupils will be selected to begin the study. The researcher is aware that Signal Hill School has a rather high transient rate and, therefore, cannot predict the exact number of pupils who will be enrolled and who will meet the specified criteria for the study at the expected date of its implementation (February and March 1982).

Independent Variables

The independent variables will be the new model instructional unit and the usual textbook instruction.

Dependent Variable

The dependent variable will be the posttest scores of the pupils adjusted for the disparity between the groups on the pretest and analyzed to determine the effects of the independent variables.

Intervening Variables

The intervening or extraneous variables may include the following:

1. Participation by students in other instructional programs such as reading could influence the posttest scores.

2. The high transient rate may reduce the number of students originally selected in the study and affect the initial randomization process and original group composition.

Experimental Procedures

The name of each child to be included in the sample group will be written on a slip of paper. The sample group will be grouped separately by sex and by grade level so there will be an equal number of boys and girls in each group and an equal number of fourth graders and fifth graders in each group. The four groups of names will be placed in four different containers. The names will be randomly selected from each container and randomly assigned to experimental and control groups until all the required subjects have been placed in the experimental or the control group.

The teacher of the control group will teach math story problem-solving skills to the control group for periods of thirty minutes each day for approximately six weeks. The total instructional time will be approximately sixteen hours. She will teach the control group in a separate classroom which is usually used as the math room. No other students will be present. She will use the basic math textbook presently being used in the Signal Hill Elementary School as

her guide (Mathematics for Individual Achievement published by the California State Department of Education and copyrighted by Houghton Mifflin). When the control teacher is not actively teaching the textbook unit on problem solving to the control group involved in the study, she will return to her regular classroom to resume her regularly assigned teaching duties.

The researcher will teach the experimental group for the same amount of time and in the same room used for the control group's instruction (the math room) but at different times. No students other than the experimental group will be in the room during the time the experimental group is being taught. The researcher will use the model instructional unit as her teaching guide.

Both teachers will teach during the morning hours. One group will be taught from 8:15 to 8:45; the other group will be taught from 9:00 to 9:30.

While the control teacher is teaching the control group in the math room, the researcher will be teaching the ESEA Title I project participants math computational skills in the control teacher's regular classroom; the control teacher's regular students will be completing a previously designated assignment.

Further exposition of experimental procedure is given in the Case Study-Experimental which is located in Appendix B.

To avoid bias, the pretests and posttests will be administered by a third teacher not involved in the study or by the school counselor. Students involved in the study will receive no additional instruction in math story problem-solving skills from the regular classroom teachers during the study.

Data Gathering

The resulting scores for the pretest and posttest of the pupils involved in the experimental model will be collected as will the test results for the pretest and posttest scores of the control group. These sets of scores for the two grades will comprise the basic data for statistical analysis.

Data Analysis

Analysis of covariance will be performed on the scores obtained from the dependent variable. The pretest will serve as the covariate. The covariance analysis tests for the significance of differences between adjusted post-test scores (adjusted for the unequal differences on the

pretest). The familiar F-ratio will be shown. Additionally, graphic presentations of the results will be depicted.

Summary

Assumptions concerning the control and experimental groups, the teachers of each group, the tests, and testing procedures have been described for this research project.

A model instructional unit which includes a sequenced continuum of instructional objectives is the focus of this study. Word or story problems will be the means by which children will be provided practice in problem-solving skills. The unit's effectiveness will be determined by administering pretests and posttests to the experimental and control groups and comparing the differences among the scores.

The total sample group will begin with fifty-three pupils randomly selected and assigned from the fourth and fifth grade classrooms at Signal Hill Elementary School.

Intervening variables will hopefully be accounted for in the determination of the unit's effectiveness via random selection and assignment.

The experimental procedures will be the random assigning of the basic sample group into the four experimental or control groups. Both groups for each class level

will be taught under the same learning situations. Only the independent variables will differ.

An analysis of covariance will be performed on the scores obtained from the dependent variables.

CHAPTER IV

IMPLEMENTATION AND DATA GATHERING

The population of the study included all the ESEA Title I project participants enrolled in the fourth and fifth grade classes at Signal Hill Elementary School in the Long Beach Unified School District. Project participants are those children who tested below the 40th percentile on the California Achievement Test--Mathematics. From this population, an experimental group and a control group were randomly selected. To equalize the groups as much as possible, the children who tested at the 5th percentile and below in reading and math were also randomly distributed into the control and experimental groups.

The study began with the control group having five girls and seven boys in the fifth grade and six girls and eight boys in the fourth grade, with a total of twenty-six pupils. The experimental group began with six girls and six boys in the fifth grade and seven girls and eight boys in the fourth grade, with a total of twenty-seven pupils.

The study ended with the control group having four girls and seven boys in the fifth grade and six girls and six boys in the fourth grade, with a total of twenty-three pupils. The experimental group ended with six girls and five boys in the fith grade and six girls and seven boys in the fourth grade, with a total of twenty-four pupils. The total sample group began with fifty-three pupils and ended with forty-seven pupils. (See Table 1.)

TABLE 1

NUMBERS OF PUPILS IN SAMPLE STUDY

	Began Study		Ended Study	
	Control Group	Experimental Group	Control Group	Experimental Group
Fourth Grade				
Boys	8	8	6	7
Girls	6	7	6	6
Fifth Grade				
Boys	7	6	7	5
Girls	5	6	4	6
Totals	26	27	23	24

The control group and experimental group were both taught in the same classroom at different times. Each group was alone in the classroom during instructional periods. Each instructional period was held thirty minutes a day

every day for six weeks and three days for a total of thirty-three days.

To eliminate as many variables as possible, instructional agreements between the control and experimental group teachers were made and abided by. The seating arrangements remained the same. Students' work, instructional bulletins, or posters concerning problem-solving skills were not displayed in the room. Neither the control teacher nor the students saw any of the teaching materials, practice sheets, or instructional procedures used with the experimental group. No extrinsic awards or incentives were used for motivation. The children who participated in the study were not told nor were they aware they were involved in a study. The regular classroom teachers did not teach problem-solving skills to student participants during the length of the study. Neither the control nor experimental group teacher assigned homework or provided students with additional help. Instruction was provided only during the instructional periods allotted in the study. The control teacher used only the materials, suggested activities, and teacher guidelines that accompany the basic math text currently used at Signal Hill School. The experimental group teacher used the materials, instructional procedures, student activities, and

student practice sheets designed for the model instructional unit.

The sequenced continuum of instructional objectives of the model instructional unit was followed and its instructional procedures adhered to. An objective with its accompanying student practice sheet was completed each day. Many opportunities were given for students to write their own story problems which were typed and copied for their classmates to solve. (See Appendix B.) Many problems were solved together as a group. Solving problems as a group involved discussions, illustrations, and demonstrations with manipulative objects. Every discussion focused on the students' understanding the numerical action happening in the story, recognizing which mathematical process was occurring and relating that process to an appropriate computational operation. Each problem was approached as a real problem-solving situation.

A third teacher not involved in the study administered the pretests and posttests. Neither the control nor the experimental group teacher was present during any of the testing sessions. The testing was scheduled by grade level groups and not by control and experimental groups.

Form 7 was given for the pretest and form 8 for the

posttest of Test M-2 (Mathematics Skills: Mathematics Problem Solving) of the Iowa Tests of Basic Skills to both the control and experimental groups. Level 9 was administered to the fourth grade pupils and Level 10 was administered to the fifth grade pupils. The reading level for Level 10 is third grade and lower and the reading level for Level 9 is second grade and lower.

Forms 7 and 8 for Levels 9 and 10 of the Iowa test contain single step problems involving addition, subtraction, multiplication, and division and include a sampling of multiple-step problems involving a combination of operations. The Iowa Test is made up of problems involving real life situations.

The adjusted posttest scores of the pupils exposed to the experimental instructional model were compared with the adjusted posttest scores of the control group.

To summarize briefly, the population of the study included all children in the fourth and fifth grades at Signal Hill Elementary School who tested below the 40th percentile in the California Achievement Test-Mathematics. Two experimental groups and two control groups were randomly selected and assigned.

Instructional agreements between the experimental and control group teacher were agreed upon to control as many extraneous variables as possible.

Levels 9 and 10 (Form 7 and Form 8) of the Iowa Tests of Basic Skills were used as the pretest and posttest. The adjusted posttest scores of the pupils exposed to the experimental instructional model were compared with the adjusted posttest scores of the control group.

CHAPTER V

PRESENTATION OF DATA

The first statistics calculated after the administration of the Iowa Tests of Basic Skills-Mathematics Problem Solving (M-2) posttest were the means and standard deviations for each group and each administration of the test. The table of pretest and posttest raw scores is located in Appendix A. In addition, the corresponding Kuder-Richardson Formula 21 estimates of reliability (internal consistency) were calculated. The results of these calculations are shown in Table 2.

Although the subjects were randomly assigned to the control and experimental groups, the differences of the means of the pretest scores suggest that random assignment was not effective. The unequalness of the mean pretest scores could also be attributed to the nonrandom or unequal loss of students from the study. The small number of students in each sample group may also have been a contributing factor to the difference of the pretest means.

TABLE 2

TEST ADMINISTRATION

		Pretest		Posttest	
		Experi-mental	Control	Experi-mental	Control
Grade 4	N	13	12	13	12
Level	Mean	5.62	8.17	10.08	8.50
(23 items)	S.D.	3.48	3.79	4.21	3.03
	K-R 21	.68	.66	.71	.44
Grade 5	N	11	11	11	11
Level 10	Mean	8.55	8.18	13.73	8.73
(25 items)	S.D.	5.66	5.86	6.36	6.51
	K-R 21	.86	.87	.88	.90

Results of Anova

An analysis of variance was performed to compare the unadjusted posttest means of the sample groups before conducting the analysis of covariance. The unadjusted posttest scores of each group were used in the analysis. The analysis of variance performed for Grade 4 pupils resulted in an F-ratio at the 1.14 level as shown in Table 3. The analysis of variance performed for Grade 5 pupils resulted in an F-ratio at the 3.32 level as shown in Table 3. Neither of these F-ratios was statistically significant.

TABLE 3

ANALYSIS OF VARIANCE OF EXPERIMENTAL AND CONTROL GROUP PUPILS (Iowa Tests of Basic Skills Mathematics Problem Solving--M-2)

	Unadjusted Posttest Scores			
Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
		Level 9 Grade 4		
Between	15.52	1	15.52	1.14
Within	313.92	23	13.65	
Total	329.44	24		
		Level 10 Grade 5		
Between	137.50	1	137.50	3.32
Within	828.36	20	41.42	
Total	965.86	21		

Note: The F-ratios on the above ANOVA tables using the unadjusted posttest scores are not statistically significant.

Results of Analyses of Covariance

Analyses of covariance were performed on the test results obtained from the administration of the Iowa Tests of Basic Skills-Mathematics Problem Solving (M-2), for Grades 4 and 5 separately. The dependent variable in each analysis was the posttest scores of the pupils. The

covariate was the pretest scores and the independent variable was the teaching method (experimental versus control).

The analyses of covariance of the control group fourth and fifth grade pupils and for the experimental group fourth and fifth grade pupils are shown in Table 4. The pupils' criterion and control variable means for the control group fourth and fifth grade pupils and for the experimental fourth and fifth grade pupils are shown in Table 5.

The analysis of covariance performed for the Grade 4 pupils resulted in an F-ratio significant at the .02 level. As can be seen in Table 5 or in Figure 1, the experimental group began with a pretest mean raw score of 5.62 and the control group began with a pretest mean raw score of 8.17. However, despite the experimental group's lower pretest score, the unadjusted posttest mean raw score of the experimental group was 10.08 while that of the control group was 8.50. The control group's mean score, therefore, was 1.58 raw score points lower than the experimental group. When the posttest means were adjusted for the differences on the pretest, the adjusted posttest mean raw score for the experimental group was 10.89 as compared to 7.62 for the control group, a difference of 3.27 raw score points in favor of the experimental group.

TABLE 4

ANALYSIS OF COVARIANCE OF EXPERIMENTAL AND CONTROL GROUP PUPILS (Iowa Tests of Basic Skills Mathematics Problem Solving--M-2)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
		Level 9 Grade 4		
Between	58.67	1	58.67	7.12*
Within	181.29	22	8.24	
Total	239.96	23		
		Level 10 Grade 5		
Between	118.77	1	118.77	10.67**
Within	211.48	19	11.13	
Total	330.25	20		

*Significant beyond the 0.02 level.

**Significant beyond the 0.01 level.

The analysis of covariance performed for the Grade 5 pupils resulted in an F-ratio significant at the .01 level. As can be seen in Table 5 or in Figure 2, the pretest mean raw scores of the experimental and control groups differed only slightly, with that of the experimental group being 0.37 raw score points higher than that of the control group. The unadjusted posttest means were 1[illegible].73 and 8.73 for the

TABLE 5

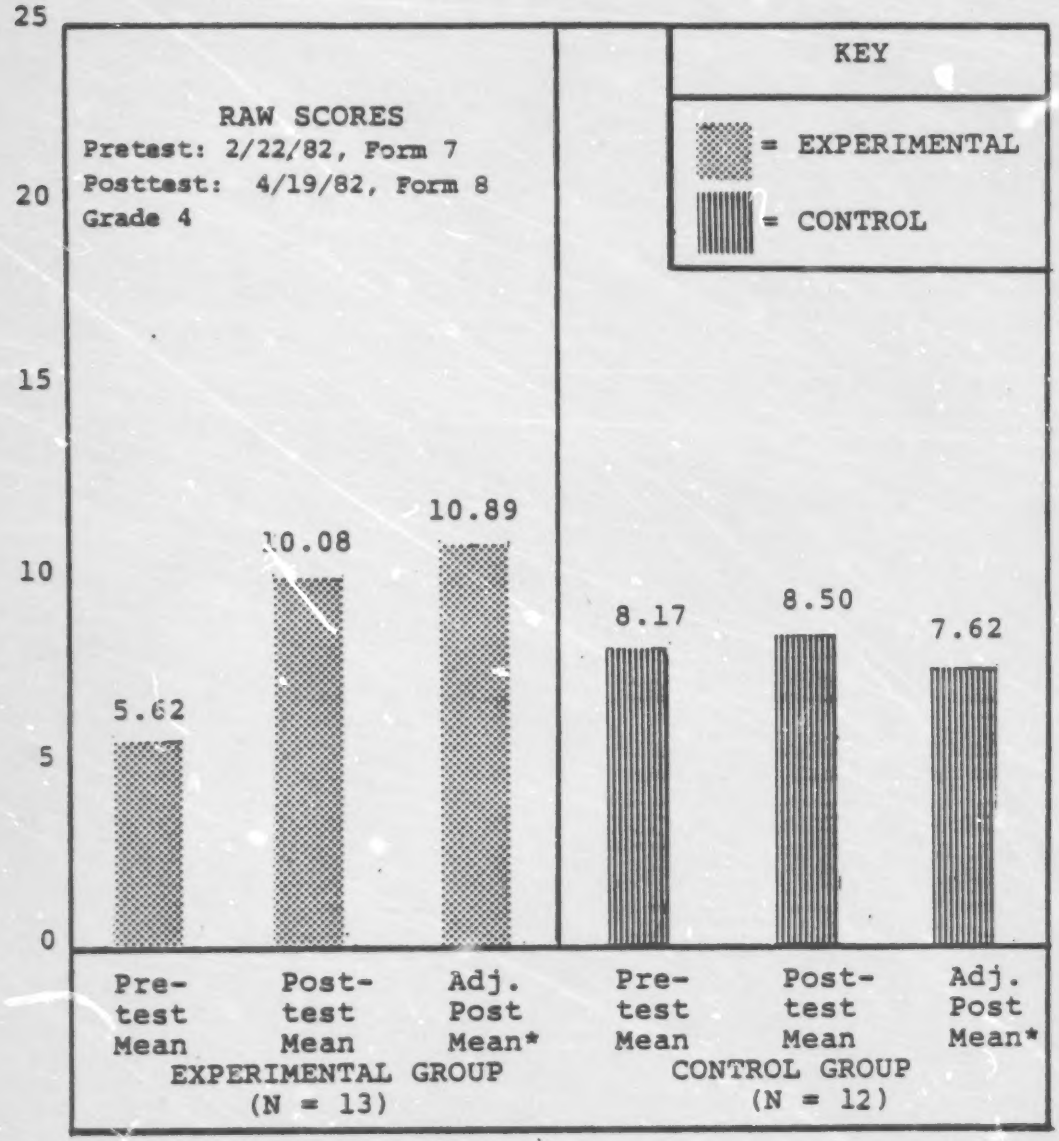
PUPILS' CRITERION AND CONTROL VARIABLE MEANS
(Iowa Tests of Basic Skills Mathematics
Problem Solving--M-2)

Group	N	Criterion Posttest Achievement		Pretest Achievement
		Adjusted	Unadjusted	
		Level 9 Grade 4		
Experimental Group	13	10.89	10.08	5.62
Control Group	12	7.62	8.50	8.17
		Level 10 Grade 5		
Experimental Group	11	13.55	13.73	8.55
Control Group	11	8.90	8.73	8.18

experimental and control groups, respectively, a difference of 5.0 raw score points. When the posttest means were adjusted for the differences on the pretest, the adjusted posttest mean raw score for the experimental group was 13.55 as compared to 8.90 for the control group, with the experimental group exceeding the control group by 4.65 raw score points.

Summary

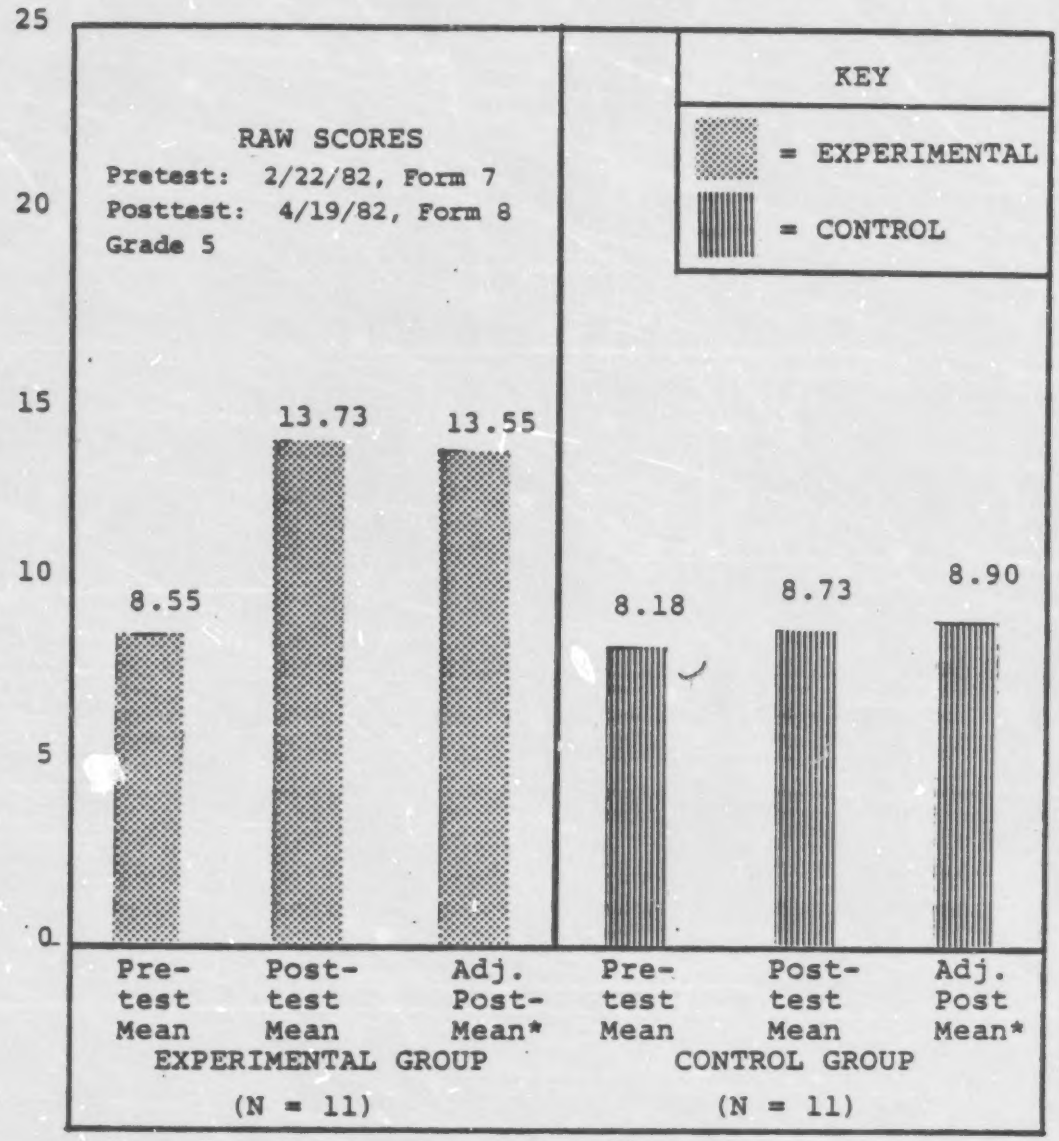
The means and standard deviations for the control group and the experimental group for each administration of



Note. An analysis of covariance testing for significance of difference between adjusted posttest scores yielded an F-ratio significant at the .02 level.

*Adjusted to compensate for differences between the groups on the pretest. Comparisons should be made between the adjusted posttest means of both groups.

Fig. 1. Mean raw scores on the Iowa Tests of Basic Skills --Level 9, Mathematics Problem Solving (M-2) for experimental and control group pupils.



Note. An analysis of covariance testing for significance of differences between adjusted posttest scores yielded an F-ratio significant at the .01 level.

*Adjusted to compensate for differences between the groups on the pretest. Comparisons should be made between the adjusted posttest means of both groups.

Fig. 2. Mean raw scores on the Iowa Tests of Basic Skills --Level 10, Mathematics Problem Solving (M-2) for experimental and control group pupils.

the test were calculated. The corresponding Kuder-Richardson Formula 21 estimates of reliability were calculated for the pre and posttests on the experimental and control group. Each calculation is depicted in Table 1.

The F-ratios resulting from an analysis of variance using the unadjusted posttest scores were not statistically significant for either group.

The analysis of covariance for Grade 4 pupils resulted in an F-ratio significant at the .02 level. The analysis of covariance performed for Grade 5 pupils resulted in an F-ratio significant at the .01 level.

There was a difference of 3.27 adjusted posttest mean raw score points in favor of the fourth grade experimental group and a difference of 4.65 adjusted posttest mean raw score points in favor of the fifth grade experimental group.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Problem solving is recognized as a major educational goal and has become an area of concern in mathematics education. The NCTM is recommending that problem solving be the focus of school mathematics in the 1980s.

The researcher has designed a model instructional unit for teaching intermediate elementary students math story problem-solving skills. It was hypothesized that children who have been exposed to the model instructional unit will show increased ability in solving mathematical story problems.

A great deal of information has been obtained about factors which influence students' learning of problem-solving skills and methods of instruction are known that improve problem-solving skills. However, practical solutions to many of the instructional problems of teaching problem-

solving skills remain unresolved.

Research must continue trying to ascertain the best methods of teaching math problem-solving skills. It is hoped that this study will contribute some practical solutions to the instructional problems of teaching mathematical problem-solving skills to elementary school children.

A model instructional unit which included a sequenced continuum of instructional objectives for teaching math story problem-solving skills was the focus of this study. Word or story problems were the means by which children were provided practice in solving mathematical problem situations.

The study included an experimental group and a control group of children randomly selected from the fourth and fifth grade students at Signal Hill Elementary School who scored below the 40th percentile in the California Achievement Test-Mathematics. The control group teacher used the basic mathematics textbook as her instructional guide. The researcher and experimental group teacher used the new model instructional unit as her instructional guide.

Levels 9 and 10 of Forms 7 and 8 of the Iowa Tests of Basic Skills-Mathematics Problem Solving were administered as the pretest and posttest for both groups.

There was a difference of 3.27 adjusted posttest mean raw score points in favor of the fourth grade experimental group and a difference of 4.65 adjusted posttest mean raw score points in favor of the fifth grade experimental group.

The analysis of covariance for the pupils in the fourth grade resulted in an F-ratio significant at the .02 level. The analysis of covariance for the pupils in the fifth grade resulted in an F-ratio significant at the .01 level.

Conclusions

It can be concluded from the results and within the conditions of this study that the Model Instructional Unit for the Development of Math Story Problem-Solving Skills for Intermediate Grade Elementary Pupils was an apparently effective means of teaching the experimental group of this study math story problem-solving skills. However, this conclusion must be tempered by the condition that use of this model unit of instruction included group-involved discussion, illustration, and demonstration of solving problems. Thus, it is the new model unit and group-involved instruction, not either alone that accounted for the differential results.

On the basis of the evidence obtained from the study, pupils who had been exposed to the model instructional unit were able to solve more math story problems as tested by Level 9 or 10 of Form 8 of the Iowa Tests of Basic Skills--Mathematical Problem Solving than were the pupils exposed to the basic textbook methods of instruction.

Recommendations

The results of this study demonstrated the model instructional unit using group problem solution techniques may have been an effective means of teaching mathematical story problem-solving skills to the experimental group of students involved in this study. The positive results of the unit's effectiveness are significant enough to warrant field studies using additional teachers and different samplings of students. Probably, level of intelligence should serve as a second covariate, and with larger samples, the study should evaluate results by grade and sex. It is recommended that future studies include populations that represent the full range of student achievement levels. The time allotted to complete this unit should be increased to extend a semester or full school year. It is recommended that teachers be instructed in the implementation of the unit before teaching

it. The instructional procedures and teacher guidelines for the student activities and use of the student practice sheets should be followed as suggested in the unit.

The amount of success other teachers will have using the model instructional unit as a guide in teaching math story problem-solving skills to a greater representation of pupils will determine the extent of the instructional unit's impact on current and future mathematic curriculums.

Long Range Consequences

As a consequence of a study that attempts to improve the math instructional programs in the elementary school, useful information may be provided for all those concerned with the beginning education of our youth and their preparation for becoming self-sufficient adults.

For the last decade the public schools have been receiving mounting public criticism. People in industry, business, and higher education often complain that the youth with whom they are dealing lack the necessary basic academic skills to perform their tasks satisfactorily. This study may stimulate a desire on the part of educators to improve the educational instructional program in the public school.

This study may provide guidelines for future instructional models within the elementary school programs of instruction in mathematics. The effective use of the math instructional model may identify teaching methods and materials that are effective in other areas of the curriculum.

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APPENDICES

APPENDIX A

PRETEST AND POSTTEST RAW SCORES

PRETEST AND POSTTEST RAW SCORES
(Iowa Tests of Basic Skills Mathematical
Problem Solving--M-2)

	Level 9 Grade 4			Level 10 Grade 5	
Fourth Grade	Pretest Form 7	Posttest Form 8	Fifth Grade	Pretest Form 7	Posttest Form 8
		Control Group Pupils			
Boys	2	5	Boys	0	0
	3	5		2	0
	9	6		0	0
	7	7		4	9
	6	9		10	10
	14	9		8	13
				14	14
Girls	6	5	Girls	9	7
	11	8		15	9
	10	11		15	15
	7	11		13	19
	14	12			
	9	14			
N=12			N=11		
		Experimental Group Pupils			
Boys	5	6	Boys	4	6
	0	7		3	7
	2	8		3	9
	7	8		19	20
	3	9		13	20
	6	11			
	8	15			
Girls	1	5	Girls	3	4
	4	8		7	14
	10	8		10	15
	7	12		8	16
	9	14		7	17
	11	20		17	23
N=13			N=11		

APPENDIX B

CASE STUDY--EXPERIMENTAL

CASE STUDY--EXPERIMENTAL

By

Florence C. Wilson

WALDEN UNIVERSITY

June 1982

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CASE STUDY--EXPERIMENTAL

Background for the Study

As a math teacher in an inner city school, I realized these children lack skills needed to solve mathematical story problems commonly used for developing mathematical problem-solving skills in the elementary school.

The low reading ability of these students is an additional handicap to their solving word problems. Even when story problems are read aloud to them, they have difficulty identifying the question, describing the problem situation, and recognizing the mathematical processes involved in the problem situation. That there is a relationship between the problem situation and the computational operation used for its solution is difficult for them to understand.

When confronted with problem situations, these children characteristically desire and often demand immediate solutions. If the solutions are not immediately known or are found to be incorrect, passive resistance or overt expressions of anger and aggression become apparent as a

means of avoiding the situation. Little patience is practiced by these children when solving problems. They seldom recognize by their own thought processes that an answer is obviously incorrect. They seek immediate answers rather than processes for solutions.

Discussion and oral communication skills are also limited in these children. It is difficult for them to repeat in their own words what the question is asking, what the problem situation is, and what mathematical process is involved in a math story problem.

Keeping these children's attention during discussions is a difficult task. Those not directly involved in the discussion tend not to listen. This situation allows only a minimum of instructional input by the teacher and hampers learning through meaningful group discussions deemed important in teaching math story problem-solving skills.

These children are in dire need of experiencing success in their academic achievements. They apparently have had few experiences in which a sequence of actions is terminated in successful completion of an objective or in the application of appropriate strategies in arriving at solutions.

Applying concepts and skills learned in one situation to other similar situations is also difficult for these children.

The learning and behavior characteristics of these children present a challenge. It was my hope that I could design a model instructional unit that would prove beneficial for the development of math story problem-solving skills in which these children could experience success. If I could design a model unit that would teach them to at least think through problem situations as presented in story problems and arrive at feasible solutions, I would consider the unit a success. Their being able to stop and think through math story problem situations and apply various problem-solving strategies to these simple story problems would indeed be gratifying.

Solution of the Problem

The instructional unit would include instructional objectives and procedures that progress from the very beginning story problem-solving skills such as identifying number processes involved in picture stories to those skills used in solving two-step math story problems. Each objective would include student activities, instructional procedures

for the teacher, and student practice sheets.

The student activities and instructional procedures chosen to be included in the unit would be those proved by research to be effective in teaching math story problem-solving skills to intermediate elementary school children.

The main purpose of this instructional unit would be to teach children to think through problem situations, to seek and use a variety of processes in arriving at solutions rather than wanting and settling for immediate answers whether right or wrong.

The thrust of the unit would be to help children understand mathematical processes involved in mathematical story problems, and to relate those processes with appropriate computational operations for solving them.

The problem story situations would be realistic ones with which children could relate. Many opportunities will be provided for students to write their own story problems for their classmates to solve.

A math vocabulary list of words and phrases commonly used in mathematics will be developed and used in each lesson to enable children to read story problems with better mathematical understanding.

With the intention of designing a model instructional

unit that teachers could use in their classrooms, I proceeded to review the latest research findings concerned with teaching mathematical problem-solving skills to elementary school children. Those findings joined with knowledge gained from years of teaching in an inner city school were used to design what I considered to be a practical and useful instructional unit appropriate for teaching children mathematical story problem-solving skills.

Research Design

My purpose for writing this unit was to provide classroom teachers an instructional unit that could be easily and effectively implemented in the regular classroom. It was my intent, therefore, to test its effectiveness under as normal a classroom situation as possible. I wanted to teach the unit myself to determine its strengths and weaknesses and make necessary changes before conducting field studies for a broader scope of evaluation. My task was to conduct the study under a normal classroom situation and yet stay within the mandates of my present teaching assignment.

Experimental research was the best possible research design for this study in spite of some limitations.

As a math specialist paid entirely from ESEA Title I funds, I am mandated to teach only project participants. These are children who have tested below the fortieth percentile on a standardized math test (California Achievement Test--Mathematics). The population of this study would of necessity be those children in our school who fit this criteria. In order to obtain an adequate number of students to conduct the study, all the project participants enrolled in the fourth and fifth grades in our school participated in the study.

The total number of students to begin the study was fifty-three. Twenty-six were in the control group and twenty-seven were in the experimental group. The experimental and control groups were determined through a process of random selection. To equalize the groups as much as possible, the children who tested at the fifth percentile and below in reading and math were also randomly distributed into the control and experimental groups.

To design an effective instructional unit for teaching mathematical story problem-solving skills to intermediate grade elementary students and to test the unit's effectiveness in an actual classroom setting were the main purposes of this study. To determine if the model unit was

more effective in teaching math story problem-solving skills than the problem-solving units included in basic math textbooks typically used by elementary teachers was also an important aspect of this study.

Pre and post criterion referenced tests were devised to determine whether or not the pupils understand basic problem-solving concepts and skills such as matching mathematical processes with mathematical operations and their symbols, matching word sentences with number sentences, and identifying correct number sentences to solve mathematical word problems.

To determine whether or not students could apply these skills in solving math story problems, the problem-solving section of the Iowa Test of Basic Skills was administered to all the study participants. The Iowa Test of Basic Skills includes a good representation of story problems made up of lifelike situations. The adjusted posttest scores of the pupils involved in the experimental model were compared with the adjusted posttest scores of the control group by the analysis of covariance.

The main thrust of the unit was to teach children to think of mathematical processes involved in problem situations and relate those processes to appropriate

computational operations. Therefore, an answer sheet was devised which required students to show their computations so their choice of operation could be determined as well as their chosen answer. A score was obtained for the number of correct solution procedures used even though the final answer was incorrect because of errors in computations. Two scores were recorded, one for the number of correct answers and one for the number of correct operations chosen.

An analysis of covariance was performed on the Iowa scores obtained from the differences between posttests administered. This analysis determined whether or not there was a significant difference between the adjusted posttest scores.

Preliminary Plans

The scheduling of fifty-three elementary school children from three different classrooms for two different periods of instruction was anticipated to be troublesome. The great cooperation from the control group teacher, the teachers involved in the study, and the principal minimized the problems. Once a routine was established, the program proceeded smoothly.

It was decided by the teachers involved in the study that teaching the unit every day would be less confusing than teaching it three days a week. Thus each instruction period was held thirty minutes a day every day for six weeks and three days for a total of thirty-three days with four additional days allowed for pretesting and posttesting.

To eliminate as many variables as possible, the control group teacher and I agreed to what we referred to as "ground rules" for the study. We adhered to those agreements without digressions during the entire study.

The same classroom was used for each group. Each group was alone in the classroom during instructional periods. The control group teacher began her lessons at 8:15 and continued until 8:45. I began my lessons immediately after from 8:45 until 9:15. The seating arrangements of necessity remained the same for each group. No bulletin boards were used to display any student's work nor were any instructional bulletins or posters concerning problem-solving skills posted in the room. The control teacher and her students never saw any of the teaching materials,

practice sheets, or instructional procedures used with the experimental group.

No extrinsic rewards or incentives other than teacher comments, and grades were used.

The control teacher used only the materials, suggested activities, and teacher guidelines accompanying the basic math texts currently used in the fourth and fifth grade classrooms at our school.

The experimental group teacher used only the materials, instructional procedures, student activities, and student practice sheets designed for the model instructional unit.

No teacher aides were used to assist during instructional periods by either teacher (except to take notes during instruction and the testing period).

The children involved in the study were told only that they were to be given instruction in math story problem-solving skills. One group was to be taught by Miss Brown and the other group was to be taught by Mrs. Wilson. This fact was readily accepted without question by the students.

The regular classroom teachers of the children involved in the study would not teach any of the children

involved in the study problem-solving skills during the length of the study. Neither the control group or experimental group teacher assigned homework, nor requested additional help from parents or the regular classroom teacher. No make-up work was given if a child missed a lesson. Each teacher instructed her students only during the instructional periods allotted in the study. No additional help was given any students after class.

A third teacher not involved in the study administered all the tests. Neither the control group teacher nor the experimental teacher was present during any of the testing sessions. The testing groups were scheduled by grade level and not by the control and experimental groupings.

An Overview

The actual teaching of the model instructional unit proved to be the most exciting and rewarding part of the study. The marvelous cooperation of all those involved in the study could not have been better. Their support and willingness to be a part of the study made it a very positive and worthwhile experience.

The children adjusted easily to the scheduling and seemed to enjoy the program once a routine was established. The students were not aware of the reason for their being

taught math story problem-solving skills in separate groups with each group having a different teacher. These children are accustomed to being pulled out of the classroom for additional instruction with specialist teachers and therefore accepted the program as merely being a part of their regular school day.

The program ran smoothly, but there were some troublesome times. Whenever twenty or more low achieving pupils in an inner city school are grouped together in one instructional group, problems are bound to occur. And they did.

Discipline was a problem during the first few weeks of the study but the behavior problems lessened as the unit progressed. Three things happened that caused behavior problems to diminish. The settling down to a routine was of itself a factor in the lessening of behavior problems. The number of children decreased as some dropped out of the program because their families moved out of the school district. The students' interest in story problems appeared to increase as they began becoming familiar with and successful in solving math story problems.

The most satisfying experience received from conducting this study was the apparent feelings of success and

satisfaction the students were beginning to experience in solving math story problems. One student approached me on the playground to tell me that she liked doing math story problems--a statement never previously heard by these ears.

Although discipline became easier as a few of the children dropped out of the program, I was forever fearful there would not be enough pupils at the completion date of the unit to provide an adequate test of its effectiveness. I was lucky. The total study ended with twenty-four students in the experimental group and twenty-three in the control group.

The first few weeks of the program were without a doubt the most difficult. The students' limited discussion skills and their desire for immediate answers were not conducive to instructional methods of inquiry and discussion. The individual student practice sheets provided with each objective proved to be invaluable. Requiring students to complete the practice sheets as the group worked together through each lesson's objective was a good practice in keeping the students' attention. Postive comments made each day about the completion of the previous day's practice sheet resulted in less discipline problems, more attentive behavior, and a greater willingness to put forth increased

effort in thinking through each objective for the day. Keeping each session a group process with positive recognition for participation had additional positive results. After the second week, children who had previously never answered questions or finished their papers were volunteering answers and completing their practice sheets.

The timing was hectic. Each group was taught back-to-back with a minimum time for transition from group to group. The close proximity of the classrooms was helpful, but the tight scheduling allowed little time to set up charts, or to arrange materials. The half-hour instructional time seemed short when each lesson was packed full of activities to be accomplished. However, as the schedule settled down to a routine, the daily time pressures began to lessen.

The necessity of completing the unit in a limited period of six weeks did cause feelings of frustration. If an objective were not achieved to my satisfaction, there was no time to re-teach or review that objective. When children were absent, which occurred frequently, no time was available for make-up instruction. Or when some children did not understand a concept, it was not possible to provide them with additional instruction. The unit was

tested under a regular classroom setting with handicaps that are not prevalent in a regular classroom situation. The element of time would not be such a problem if the unit were taught during an entire school year or semester.

The shortage of time and the learning characteristics of the students involved in the study gave little encouragement for any great improvements in test scores. But if these children could at least show increased skills in discussing story problems, and derive pleasure from the process of solving them, the unit could very well be considered a positive contribution to the teaching of math problem-solving skills to elementary school children.

Implementation

The first weeks of instruction were spent demonstrating and illustrating mathematical processes and relating each process to a computational operation. This concept of relating a mathematical process with a computational operation was difficult for children to understand. More time was required for teaching this concept that anticipated. Even though students appeared to understand a math process and its relation to an operation during an illustration or demonstration, it was difficult for them to recognize and

identify math processes when they occurred in math story problems.

An important aspect of the unit was to spend five to ten minutes each day on the development of a math vocabulary. To complete the unit in the allotted time required that the entire period be spent on the completion of each objective. Thus, the vocabulary development sessions were regretfully discontinued. Many opportunities were given for students to write story problems of their own which were typed and copied for their classmates to solve.

The first time students were asked to write story problems they experienced a great deal of difficulty. It was necessary to write several story problems as a group before many of them could do so on their own. Their first problems were very simple and usually involved the process of taking objects away. Gradually their problems became more complicated and involved other operations. Two-step problems began to appear as they were introduced in the lessons. The story problems the students wrote provided the group with interesting practice problems with which students could relate and served as a positive form of motivation. (See sample on following page.)

As the unit progressed, the group settled to a

PUPILS' STORY PROBLEMS

1. There were two boys on the field. Then 10 more kids came to play football. How many kids are playing football? _____
(By Keith)

2. Jim bought 2 candy bars. His father bought 3 candy bars. How many candy bars did Jim and his father buy? _____
(By Maria)

3. I went to the store and bought two boxes of candy bars. There were 10 bars in each box. How many candy bars did I buy? _____
(By Clinton)

4. There were 12 kids in our class who wore glasses last year. This year there are 14 kids who wear glasses. How many more kids wear glasses this year than last year? _____
(By Lois)

5. I went to the toy store. I had $4.90. I wanted a doll that costs $5.80. I had to borrow money from a friend. How much did I borrow?
_____
(By Jo Anna)

6. Sue went to the store and she got a dollar's worth of oranges. How many oranges did she get? The oranges were a quarter each. _____
(By Michelle)

7. Tom went to K Mart and bought twenty-five pencils. Then he went to the school store and bought fifteen more. He got to class and gave eight of the pencils away. Hom many pencils does he have now? ____
(By La Tonya)

8. Patrice went to the store and bought a pet dog. The pet costs $20.00. She had two dollars more than $20.00. How much money did she have? _____
(By Wendy)

9. Carla went to the store. She bought 4 dozen eggs for $1.50 a dozen. How much money did she give the cashier? _____
(By Coleen)

routine of achieving the objective of the day and completing its accompanying student practice sheet. The remainder of each period was used for applying skills and concepts previously learned for solving problems provided in the unit or written by the students.

Working through story problem solutions involved discussions, illustrations, and demonstrations with manipulative objects. A routine set of questions was never established to be used with every story problem situation. The questions, the number of questions, and their sequencing changed with each problem situation. No set pattern of solution procedures was established. Each procedure varied with each problem situation.

Every discussion focused on the students' understanding of the numerical action happening in the story, recognizing which mathematical process was occurring and relating that process to an appropriate computational operation. The questions and procedures used in solving each problem were those thought to be most appropriate in helping the students understand the mathematical process involved and relating that process to an appropriate solution procedure.

Each problem situation was either read aloud or

silently. The problems were read aloud by a student or myself. The children enjoyed reading aloud and this practice resulted in good interest and attention. My reading the stories aloud enabled me to emphasize certain parts of the story, pause, stop, or ask questions if important to do so for better understanding of the problem situation and its solution.

Children were often asked to explain in their own words what was happening in the story and what mathematical process was occurring. They were often asked to reread or underline the question and to repeat the given facts.

A separate objective in the unit provided students instruction in determining the reasonableness of answers. After finding a solution, questions to determine the reasonableness of an answer was seldom asked directly such as, "Is that reasonable?" Questions such as, "Could Father really drive 128 miles to work every day? Would you get $1.68 in change after giving the clerk a one dollar bill? Would thirty-two children make four teams with eight children on each team?" were asked to encourage and guide their thinking.

A conscious effort was made to provide an adequate wait time for children to answer each question. The wait time varied from two to eleven seconds. However, when the

child called upon did not answer immediately, other children often answered. They were forever being reminded to be more patient with one another.

The use of horizontal number sentences was adhered to during the first weeks of the unit's implementation but was discontinued after its use was no longer considered beneficial to the students' solution procedures. A student could not write a number sentence until after the computational operation was decided upon. Therefore, it was quicker, easier, and less confusing to set the problems up ready for computation and eliminate horizontal number sentences. Example:

$\begin{array}{r} 75¢ \\ -28 \\ \hline \end{array}$ rather than $75¢ - 28¢ = \square$ or $4\overline{)644}$

rather than $644 \div 4 = N$.

The use of key or cue words was not emphasized as a means of determining which computational operation to use as a solution. Key or cue words were referred to only when they were considered beneficial in understanding the mathematical process involved in a problem situation.

Throughout the unit, students had difficulty working independently. They lacked confidence in their own abilities

to solve problems and lacked sequencing skills necessary in solving the simplest problem situations. A successful instructional procedure was guiding them through the process of solving many story problems. Each day several story problems were worked through as a group as they recorded their computations on their practice sheets. The number of story problems required to be solved independently was gradually increased as the students became more confident.

As the children worked independently and with each other, I walked about giving help whenever it was needed. Help consisted of telling them words they did not know in the story problem, asking leading questions concerning the question that was being asked in the problem, the facts that were given, the problem situation and its solution procedures, and assisting them in "setting up" the computations necessary for problem solutions. These independent work periods proved to be especially beneficial for my determining the difficulties children were experiencing in solution procedures.

The fifth week of instruction seemed to be the turning point of the unit. Students were beginning to think more about processes and solutions rather than desiring immediate answers even though they were still experiencing

some difficulty in explaining processes used in obtaining solutions. Subtraction involving the process of taking objects away was the easiest concept to understand and explain. The process of division was the most difficult.

By the end of the fifth week, independent work periods were increased to fifteen minutes. Children began to work in small groups discussing among themselves how each problem should be solved. This behavior indicated a big step towards their becoming involved, interested and proficient in solving math story problems.

Students began lingering in the room trying to finish more problems rather than returning to their regular classrooms.

While discussing a solution procedure during the last week, one child had worked ahead of the group. He raised his hand and declared that he had found the same answer a different way. Not only was it correct, but he was able to explain the process he used in solving it. Hearing this student explain a solution procedure that was uniquely his own was one of the highlights of the unit.

There was a decided difference in the students' attitudes, behavior, and quality of discussion between the first and last lesson of the unit. During the last lesson,

they were more interested and more on task. Their answers reflected thought on processes and operations rather than just answers. Explanations of answers were coming more readily.

During the independent work period, students exhibited more self-confidence. Their attitudes were more positive. They were beginning to feel good about their ability to solve math story problems.

The days of posttesting were the most apprehensive. Tests were administered by a third teacher not involved in the study and the tests were scheduled by grade level rather than by control and experimental groups.

Conflicts in scheduling, absenteeism, and suspensions resulted in the posttesting taking a total of six days to complete. Each day a child was not at school I was fearful the family had moved away.

The teacher aide who took notes during the experimental instructional periods also took notes during the testing periods. It was noted that the fourth grade students were generally more apprehensive and unsure of themselves during the testing periods than were the fifth grade students. The fifth grade students tackled the tests with more self-confidence and less questions. However, the

students in the experimental group on both grade levels were generally more positive and delved into the tests with more self-confidence. The experimental group's ability to work independently during testing surpassed the control group's ability to do so.

The big question is, "Were the experimental group's positive attitudes and feelings of self-confidence truly an indication of their increased ability to solve mathematical story problems?"

Interpretation of Results

Positive attitudes and feelings of self-confidence must be supported by hard test data to prove the success of any instructional unit.

The adjusted posttest mean raw score (adjusted for the differences on the pretest) for the fourth grade pupils in the experimental group was 10.89 as compared to 7.62 for the control group. This is a difference of 3.27 raw score points in favor of the experimental group.

The adjusted posttest mean raw score (adjusted for the differences on the pretest) for the fifth grade pupils in the experimental group was 13.55 as compared to 8.90 for the control group. The experimental group exceeded the

control group by 4.65 raw score points.

The analysis of covariance performed for the Grade 4 pupils resulted in an F-ratio significant at the .02 level.

The analysis of covariance performed for the Grade 5 pupils resulted in an F-ratio significant at the .01 level.

The data used for the analysis was the number of correct answers given for the Iowa Test of Basic Skills, not the number of correct solution procedures. The difference between the number of correct answers and the number of correct operations used with incorrect computations was too small to warrant analysis of that data.

The criterion referenced test designed by the researcher had not been normed and could not be considered as valid or reliable for this study and, therefore, was not used in the study proper.

Conclusion

It can be concluded that this model instructional unit seemed to be an effective means of teaching the experimental group of this study math story problem-solving skills.

On the basis of the evidence obtained, the experimental group exposed to the new instructional unit was superior on the Iowa Tests of Basic Skills-Problem Solving (M-2).

Recommendations and Future Plans

It is yet to be determined if other teachers using the model instructional unit will obtain positive results in different schools with different groups of children. Field studies should be conducted to determine if in fact this model instructional unit will be equally successful for other teachers. Only then can the extent of its impact on current mathematic curriculums be determined.

It is recommended that the instructional unit extend over a semester or an entire school year. Additional time would allow for math vocabulary development and greater mastery of each objective.

An ideal group size is ten students. Small groups are recommended for greater student participation during discussions, and for more effective use of manipulatives. Small groups allow the teacher to observe and ascertain ways in which each child approaches and solves problems, and to determine the many various problem-solving techniques children use in solving problems. More opportunities are possible for children to verbalize the mathematical processes involved in each problem situation when small group instruction is used.

A specific objective for teaching children how to make and use simple drawings as an aid in identifying mathematical processes involved in problem situations will be added to the unit. Although drawings were used to explain and demonstrate many of the story problems, the students never applied the use of drawings as a means of determining which math processes were involved in the problem situations. More direct instruction in the use of drawings is evidently needed if children are to be expected to apply this technique to their solution procedures.

Use of horizontal number lines should not be emphasized or encouraged in solution procedures. Children often attempted to compute problems in a horizontal position which caused them to compute incorrectly. Once an appropriate operation to solve each problem is determined, students should be instructed to write the problem in whatever position is most conducive to quick and accurate computation.

The positive results obtained from this study warrant a more extensive study of this model instructional unit for teaching elementary students math story problem-solving skills. Field studies involving additional teachers and larger samplings of students divided by sex, grade levels,

ethnicity, ability, and so on need to be conducted before its worth as an instructional program can be determined.

It is recommended that teachers be instructed in the use of the unit before teaching it. Specific instructional procedures are advised. It is imperative that a positive and success-oriented approach be followed. The instructional procedures and teacher guidelines for the student activities and use of student practice sheets should be adhered to as suggested in the unit.

APPENDIX C

DESCRIPTION OF THE MODEL UNIT

DESCRIPTION OF THE MODEL UNIT

The Model Instructional Unit for the Development of Math Story Problem-Solving Skills for Intermediate Grade Elementary Pupils includes a sequenced continuum of instructional objectives, guidelines for the unit's implementation, student practice sheets, a math vocabulary list, charts and word phrases, and a criterion referenced pretest and posttest.

The unit itself is divided into two sections. One section consists of the objectives with accompanying teacher guidelines and student activities. The second section consists of the student practice sheets.

Guidelines for implementing the unit include grouping instructions, time allotments, and instructional and testing procedures. Good teaching practices for more effective learning are also included.

The instructional objectives are carefully sequenced to maximize student success. The objectives progress from students' identifying and relating numerical activities in

pictures to solving two-step math story problems. Student activities, teacher guidelines, examples to use for demonstration purposes, and student practice sheets accompany each objective.

The student practice sheets provide the student with follow-up material to practice the skills learned in each objective. They are suitable for independent and/or group exercises.

A math vocabulary list made up of words most frequently used in the unit is compiled for easy teacher use. The vocabulary words are listed with the objective and practice sheet number in which they are introduced. The more difficult words are listed as review words when they appear in succeeding objectives and practice sheets.

Side-steps are provided with each objective that is considered a crucial step in the process of learning how to solve mathematical story problems. Side-steps include additional student activities, instructional procedures, and student practice sheets which provide students additional practice in mastering those skills deemed essential to master before proceeding to the next objective.

Instructional procedures include demonstrating with magnets on a magnetic board and other manipulatives, and by

drawing simple illustrations to demonstrate and explain the mathematical processes involved in each problem. Student activities include discussions, dramatizations, and simple drawings to depict the problem situation.

The math story problems included in the unit provide the students with contrived real life situations to which problem-solving skills can be applied. They are relevant and interesting to children. The reading level of the story problems is on approximately the third grade level and lower as determined by the Edgar Dale and Jeanne S. Chall formula for predicting readability (Chall, 1958).

Each story problem is approached as a problem-solving situation. Students are asked to think about the situation and what is happening in the problem. They are asked to associate the numerical action of the situation to a mathematical process. That process is then related to appropriate computational operations for determining the problem's solution.

A criterion referenced pretest and posttest are included in the instructional unit. The tests cover the same material but are presented in two different forms. The purpose of the tests is to determine whether or not students achieve the objectives of the unit.

The sequence of objectives, choice of student activities, instructional procedures, selection of story problems, time allotments and the student practice sheets are considered suitable for use with most intermediate grade elementary pupils. The unit is recommended to be taught during one school year or a semester to be most effective.

Reference

Chall, Jeanne S. Readability: An Appraisal of Research and Application. Columbus: Educational Research Department, Ohio State University, 1958.

OBJECTIVE # 7

To write a question when two facts are given.

Student Activity: Students will write a question using two given facts.

Teacher Guidelines: Write two numerical facts on the chalkboard or on a chart. Have children write and then read aloud their questions. Let the group decide whether or not each question is appropriate for the given facts.

Example: Fact: Milk costs 35¢ a glass.
Fact: Orange juice costs 55¢ a glass.
Question: _____

Discuss with the children which mathematical processes would be involved in each problem situation.

Use Practice Sheet No. 10.

PRACTICE SHEET NO. 10

Objective # 7: To write a question when two number facts are given

Write a question using the two given number facts.

1. Fact: A cotton shirt with long sleeves costs $25.00.
   Fact: A cotton shirt with short sleeves costs $23.00.
   Question: _____
   _____

2. Fact: The regular price for a hammer is $16.09.
   Fact: The sale price for a hammer is $12.39.
   Question: _____
   _____

3. Fact: Notebooks are on sale for 49¢ each.
   Fact: Mother bought 4 notebooks.
   Question: _____
   _____

4. Fact: Tina paid $20.00 for the blouses she bought.
   Fact: She bought 2 blouses.
   Question: _____
   _____

5. Fact: Dad bought a computer question and answer game that cost $16.98.
   Fact: Dad bought another game for $17.20.
   Question: _____
   _____

6. Fact: An eleven inch checker game cost $7.95.
   Fact: Mom bought one game and gave the clerk a ten dollar bill.
   Question: _____
   _____

OBJECTIVE # 19

To identify story problems that do not have enough information for their solution and identify what information is missing.

Student Activity: Children will decide whether or not enought information is provided in a given problem situation. If necessary information is not given, children will decide what information is needed to solve the problem.

Teacher Guidelines: Write several story problems on the chalk board, a chart, or ditto sheet that do not provide enough information to solve them. Read each problem with the students. Discuss whether or not enough information is provided to solve the problem. If there is not, have children supply needed information.

Example: Mother went shopping and bought a package of lunch meat for 95¢ and a loaf of bread. How much did she spend for the lunch meat and bread?

Do you have enough information? _____
What information is needed? _____
_____

Use Practice Sheet No. 31.

PRACTICE SHEET NO. 31

Objective # 19: To identify word problems that do not have enough information for their solution and identify what information is missing.

Read each problem carefully. Decide whether or not there is enough information to solve the problem. Tell what information is missing.

1. Mother went shopping and bought a new blouse for $18.75 and a new skirt. How much did Mother spend on new clothes?

   Do you have enough information? _____
   What do you need to know? _____
   _____

2. Mother went shopping for some new clothes. She bought a new blouse for $18.75 and a new skirt for $24.50. How much money did Mother spend on her new clothes?

   Do you have enough information? _____
   What do you need to know? _____
   _____

3. The teacher in the first grade classroom was handing out new crayons. She has 35 boxes of crayons. There are 8 crayons in each box. How many crayons are there?

   Do you have enough information? _____
   What do you need to know? _____
   _____

4. The teacher has 35 boxes of crayons. She gave each child a box of crayons. How many boxes of crayons were left over?

   Do you have enough information? _____
   What do you need to know? _____
   _____

5. There are 33 children in the second grade. How many more pencils did the teacher need?

   Do you have enough information? _____
   What do you need to know? _____
   _____

BIOGRAPHY

Name:	Florence Catherine Koopman Wilson
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Grammar School:	Artesia Pioneer Grammar School, Artesia, California
High School:	Excelsior Union High School Norwalk, California
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	Teacher, Grades 1-6 Counselor, K-6 Learning Disability Group Teacher Reading Teacher Specialist Math Teacher Specialist